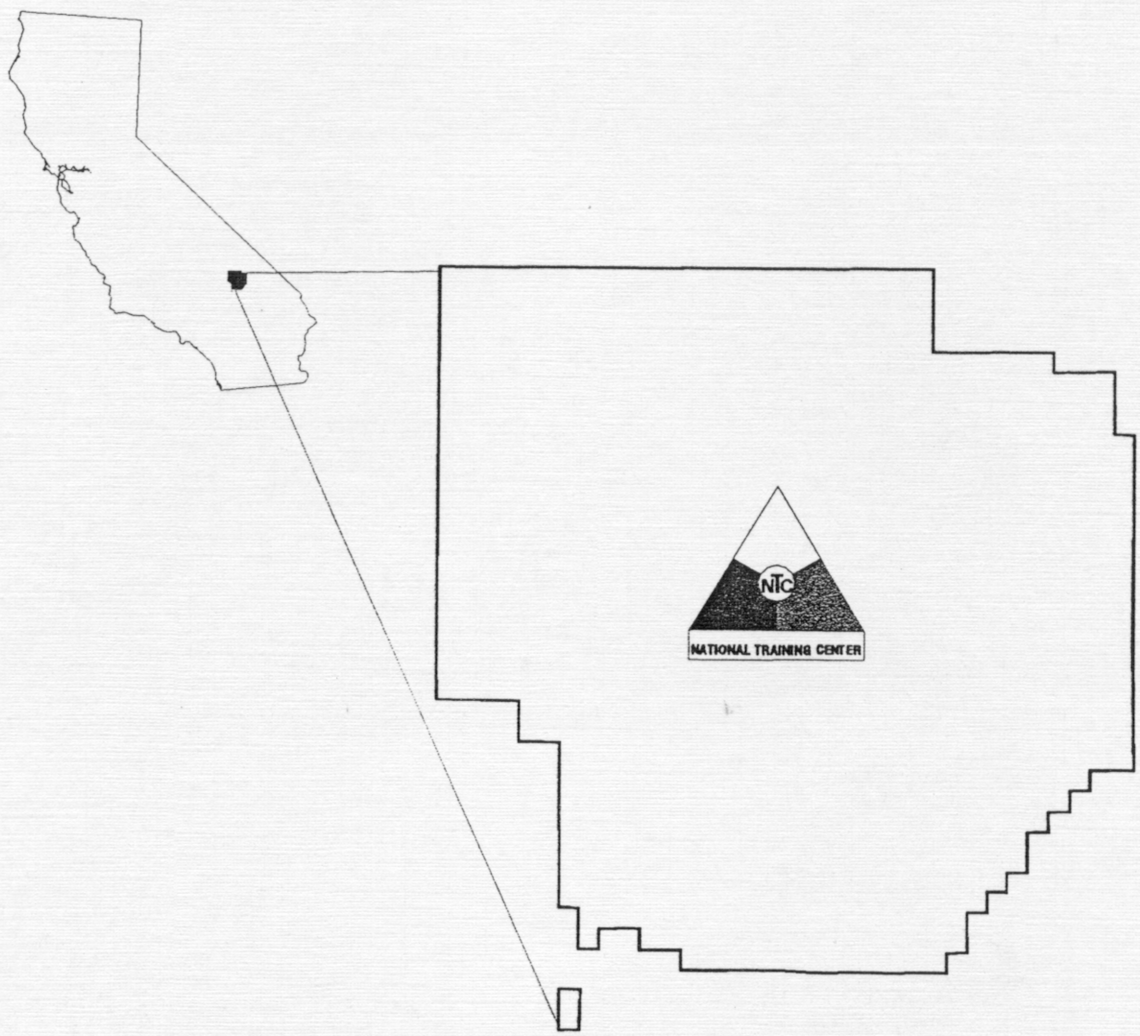
1994 AVIAN SURVEY

National Training Center, Fort Irwin, California

January, 1996



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ROBERT D. NIEHAUS, INC.

FINAL REPORT

1994 AVIAN SURVEY AT THE NATIONAL TRAINING CENTER, FORT IRWIN, CALIFORNIA

Prepared under contract with

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Contract Number DACA09-93-0027

Project 96.2

January 1996

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1. INTRODUCTION

Fort Irwin National Training Center is a United States Army Training Base located in the Mojave Desert of California, approximately 30 miles northeast of the city of Barstow. The base covers an area of about 1000 square miles and is intensively used for the training of troops in desert warfare. As part of Fort Irwin's ongoing commitment to study the biological diversity of the base and the effects of training on it, a contract was awarded in 1994 to investigate the avian fauna. The charge of the study is to "determine species occurrence and compare composition of avian communities from one habitat type to another." Special attention is to be paid to Common Raven abundance and Federal or State Listed species.

Previous work concerning Fort Irwin includes three reports by Anthony Krzysik, a bird list provided by Tom Clark, and a report by Deborah Clark on the 1991 Land Condition-Trend Analysis (LCTA) wildlife inventory.

Anthony Krzysik's (1985) report on the effect of training on Ft. Irwin discusses the results of an experimental study conducted by Krzysik in April, 1983. He surveyed 16 strip transects for breeding birds. There were five sites surveyed: two controls (Goldstone), plus severely, moderately, and lightly disturbed sites. The surveys were conducted during a markedly wet year, as evidenced by the presence of breeding Western Meadowlarks on his survey plots. He found no significant difference in breeding Horned Lark densities between disturbed and control sites. However, numbers of breeding Black-throated Sparrows were significantly different between the severely disturbed site and one of the Goldstone controls. Brewer's and Sage Sparrows were classified as "sensitive indicators of habitat damage," and Black-throated Sparrows and LeConte's Thrasher "tolerated moderate disturbance" based upon Canonical Analysis of Discriminance. He also found that "habitat disturbance had a profound negative effect on bird biomass." Unfortunately, this study is flawed by 1) being conducted in an unusually wet year and therefore not representative of "average" conditions, and 2) the disturbed and control plots were taken from very different areas and were not comparable.

In 1990, Krzysik published a report on threatened/endangered/sensitive species at Ft. Irwin. In it, he stated that Horned Lark foraging flock density in the Southern Corridor was the same as at the Goldstone control in 1984 (a drought year) Krzysik saw State Threatened Least Bell's Vireo at Bitter Springs in 1986, but no other federal or state listed species had been seen at Ft. Irwin. California State "Species of Special Concern" seen at Ft. Irwin were: Golden Eagle, Burrowing Owl, Black-tailed Gnatcatcher, LeConte's Thrasher, Cooper's Hawk, Prairie Falcon, Yellow Warbler, Northern Harrier, Long-eared Owl, White-faced Ibis, and California Gull.

In a later, similar report by Krzysik (1994), he adds California Department of Fish and Game "Special Animals": Black-crowned Night Heron, Snowy Egret, Great Egret, and Great Blue Heron to his list of endangered/ threatened/sensitive birds known to occur at Ft. Irwin.

Deborah Clark, in her (1992) Land Condition-Trend Analysis (LCTA) wildlife inventory, gives information about bird surveys conducted in 1991. Surveys were conducted in April, May, and June on 34 plots of unspecified size and location. The report states that two people worked together to do the data collection and that 68 person-hours were spent, so it seems likely that each plot was visited only once, for an hour each time. A total of 209 individuals of 23 species were seen. The most common species were: Horned Lark (N=79), Black-throated Sparrow (N=66), Rock Wren (N=35), Mourning Dove (N=12), and Brewer's Sparrow (N=10). No birds were seen on one transect (3% of transects), 1-5 birds were seen on 14 transects (41%), and 6-28 birds were seen on 19 transects (56%). In her report, Clark states that the methods she used do "not produce adequate data for making general comparisons of overall density, bird species diversity or number of species in different habitat types."

Tom Clark (personal communication) has provided a bird list for Fort Irwin. He lists 110 species seen at Ft. Irwin. California "Species of Special Concern" are: White-faced Ibis, Cooper's Hawk, Golden Eagle, Prairie Falcon, Long-billed Curlew, Black Tern, Vaux's Swift, LeConte's Thrasher, Loggerhead Shrike, and Yellow-breasted Chat. California "Special Animals" are: Western Grebe, Great Blue Heron, Great Egret, Snowy Egret, and Black-tailed Gnatcatcher.

2. MATERIALS AND METHODS

Walking Transects

Thirteen walking transects were monitored in 1994. Transect locations were chosen to sample representative habitats on the NTC (primarily creosote habitats). As this study was intended to be preliminary to later disturbance studies, the emphasis was placed on lightly disturbed and undisturbed areas to establish baseline data. Whenever possible, sites were chosen to coincide with those of other groups, especially those of the vegetation team, whose results are used in data analysis. See Table 1 for coincidence of bird transects with other studies. The dates transects were visited and transect UTM coordinates are given in Table 2, and transects are shown on Maps 1-5.

The transects were standardized to one kilometer in length, and subdivided into ten 100 - meter segments. Walking transects are two parallel 500m segments, separated by a 100m spacer. The end point of the transect is 100m from the start point. This configuration saved the time of walking 1km back to the start, so that more transects could be covered during the short peak activity period for birds. The same two observers were used to perform all transect observations. At approximately a ten meter distance from each other, the two observers walked the transect, recording all birds identified, along with observations on singing, nesting, territorial displays, and other behaviors. Observations were sited to a 100-meter segment. Each walking transect was repeated a total of eight or nine times, four or five times in the spring, and four times in the fall. Transect order was systematically rotated so that biases in results caused by the different start times would be avoided. Data were subjected to statistical analysis (see below).

Driving Transects

Driving transects were conducted on three separate routes, two times each in the spring, and two more times in the fall (see Table 2 and Map 6 for driving transect locations). Transects were run once in each direction in the Spring and again in the Fall. Transect protocol was a modification of the U.S. Fish and Wildlife Service Breeding Bird Survey. Because of limited road length at Goldstone Deep Space Tracking Station and to maintain consistency between transects, transect length was set at 20 miles. Stops were established every half-mile along the route, for a total of forty stops. Transect runs started approximately one-half hour before sunrise and continued until all stops had been made. At each stop a timed three minute observation was conducted, where all identifiable birds were recorded. This included individuals identified by sound alone as well as by sight. In accordance with U.S. Fish and Wildlife Service protocol, one observer was used for all observations on all transects. Data were subjected to statistical analysis (see below).

Spot Birding

In addition to the above quantified techniques for measuring bird density and diversity, a qualitative method, called "spot birding," was used to assay birds in areas where a transect was not suitable (areas too small for a 1 km transect, areas of dense vegetation, areas where, because of the limited time and scope of the work, transects were not established). Often, areas surveyed by spot birding were wetlands. With this technique a site was visited, spending an indefinite period of time recording birds. Most sites were visited repeatedly in the spring and fall. This method of census is responsible for most of the bird diversity recorded on the

NTC in 1994. See Table 3 and Map 6 for sites visited in 1994.

Statistical Analysis

Statistical analyses were conducted using StatView SE + Graphics (for Macintosh computers) version 1.03 and 4.5. Tests included Analysis of Variance (ANOVA), Pearson's correlation coefficient, and Regression Analysis. See Appendix A for formulas and sample calculations for these statistical tests.

Walking transects were classified according to habitat type, topography, and level of disturbance (Low, Medium, or High, see Table 4 for classifications). Included in the database for analysis were elevation, distance to water, Julian Date (the number of days from January 1), start time and time spent on the transect.

Walking transect analyses were conducted using data collected for plants and soils (collected in 1994) by Ana Ferrus-Garcia and Vern Burlingame, members of the investigating team. Through consultation with these other investigators, a correspondence was developed among avian transects for this study, vegetative transects run by Ms. Ferrus-Garcia and soil samples taken by Mr. Burlingame (see Table 1 for overlap between bird transects, vegetation transects, and soil sampling).

Because vegetation data were only available for seven of the thirteen transects and not at all for driving transects, a significant part of the data was not available to analyze for habitat associations. Additionally, data were very limited concerning the topography and level of disturbance of these transects. In an attempt to analyze the data more fully, a ranking system was constructed for all the transects based upon scoring (range = 1-5; 5 being the best possible) the amount of pristine habitat, vegetation diversity, water availability, perch availability, and topographic heterogeneity (see Table 5). The scores were based upon considered judgment, not upon measurement. The summed ranking and the individual rankings were tested for association with species number, number of sightings, and the occurrence of individual species.

3. RESULTS

3.1 WALKING TRANSECTS

A total of 560 birds of 46 species were seen during 108 iterations of the 13 walking transects (see Appendix B for walking transect summaries). Of the 560 sightings, 372 (66%) were seen in the spring and 188 (34%) were seen in the fall (because each transect was monitored eight or nine times during the year, a sighting may not represent a unique individual). Of the 46 species seen, 38 (83%) were seen in the spring and 21 (46%) were seen in the fall (the numbers of species are not additive because 13 species are shared between spring and fall). The number of sightings seen is highly correlated with the number of species [$r(106\ df) = .818$; $p < .01$], indicating that areas with high species diversity are also areas with large numbers of birds. Looking at the year as a whole, six species were responsible for 71% of all sightings and 15 species were responsible for 85% of all sightings (see Figs. 1, 2, and 3). In the spring, seven species accounted for 72% of sightings, whereas only three species yielded 71% of all sightings in the fall.

There were highly significant differences between transects as shown by Analysis of Variance (ANOVA), both for number of sightings [$F(12,82) = 4.972$; $p = .0001$] and for number of species [$F(12,82) = 11.222$; $p = .0001$; see also Figs. 4 and 5). In an attempt to explain the differences between transects and predict bird distribution, a variety of statistical methods was used to examine the effects of season, habitat, topography, and level of disturbance on these transects (see below).

A. Season

Differences between seasons were highly significant, both for numbers of sightings [$F(1,82) = 18.341$; $p = .0001$] and for numbers of species [$F(1,82) = 28.698$; $p = .0001$]. Two factor ANOVA of transect and season also showed significant levels of interaction between the two factors, both for number of sightings [$F(12,82) = 2.018$; $p = .0326$] and number of species [$F(12,82) = 1.921$; $p = .0433$], indicating that transects were differently affected by the change of seasons. Because of the difference between seasons, data were split into spring and fall. Creosote bush habitats also showed highly significant differences between season, for numbers of sightings [$F(1,51) = 7.857$; $p = .0071$] and numbers of species [$F(1,51) = 14.155$; $p = .0004$], however, no interaction between transect and season was seen, either for numbers of sightings [$F(7,51) = 1.503$; $p = .1874$] or for numbers of species [$F(7,51) = 1.526$; $p = .1798$]. Within the spring and fall seasons there was no significant correlation between Julian date (number of days from the beginning of the year) and numbers of sightings or species. Therefore, within the period when measurements were taken, bird abundance and diversity did not change, and sites surveyed at the end of the field season can be compared directly with sites surveyed at the beginning.

B. Habitat

There were differences between transects when grouped according to habitat type. Two-factor ANOVA of habitat and season showed significant differences for numbers of sightings [$F(5,96) = 3.10151$; $p = .0122$] and highly significant differences for numbers of species [$F(5,96) = 11.41462$; $p = .0001$]. The blackbush habitat surveyed in the Avawatz mountains was by far the richest habitat, both for sightings and for species. ANOVA comparing creosote to all other habitats showed creosote bush habitats to be significantly lower in numbers of sightings and numbers of species [$F(1,106) = 5.453; p = .0214$ for sightings, $F(1,106) = 15.163; p = .0002$ for species]; creosote bush habitats were considered separately. Eight creosote bush habitats also showed highly significant differences for number of sightings [$F(7,51) = 4.704$; $p = .0004$] and for number of species [$F(7,51) = 14.141$; $p = .0001$].

In order to examine the relationship of birds to habitat, measured variables related to vegetation, soil, and elevation, and ranked, non-measured variables were used (see Materials and Methods and Table 5). Using non-measured variables permits analyzing the entire database, while only about half of the data can be analyzed using measured variables. The vegetation measures were compared to the non-measured variables. Perennial percent cover, perennial species richness, creosote bush relative cover, annual species richness, and annual biomass were correlated with total ranking, amount pristine, vegetation diversity, H_2O availability, perch availability, and topographic heterogeneity (for results, see Table 6). Vegetation diversity was most highly correlated with four of the five vegetation measures. Total ranking correlated second-best with four out of five measured variables, and amount pristine and H_2O availability had no significant relationship to any vegetation measures. How powerful are these variables in predicting bird abundance and diversity? Regression analysis was used to compare the numbers of sightings and species with the above variables, elevation, and soil pH and permeability (see Table 7). Results are discussed below. Most of these data were highly inter-correlated (see Table 6), and multiple regression could not be used to study the simultaneous effects of more than one variable at a time (high levels of intercorrelation can cause inaccurate results or are incalculable).

B1. Spring Birds

While most variables were significantly related to spring bird abundance and diversity, perennial species richness was the best predictor of number of sightings, explaining 74.8% of the variation by that factor alone (the predictive power of the regression is a function of the adjusted r^2: the proportion of the total variation in the dependent variable that can be explained by variation in the independent variable; for example, see Table 7). Annual species richness was the best predictor of number of species, explaining 79.1% of the variation. For non-measured variables, total ranking was the best predictor of both sightings and species (adjusted r^2's of .367 and .499, respectively). Across the board, non-measured variables were much more loosely (that is, possessing lower adjusted r^2 values) linked to birds than were measured variables. Soil pH, permeability, and H_2O availability had no significant relationship to spring bird numbers or diversity. Multiple regression using non-measured variables increased predictive power somewhat. For numbers of sightings, a combination of vegetation diversity and amount pristine gave a slightly higher adjusted r^2 than total ranking [$F(2,55) = 17.125$; adj. $r^2 = .370$; $p < .01$]. Topographic heterogeneity and vegetation diversity increased the adjusted r^2 for number of species to .528 [$F(2,55) = 31.709$; $p < .01$].

B2. Fall Birds

The power of regression to predict fall birds is considerably less than it is for spring birds. The variable that best predicts bird abundance is creosote bush relative cover, explaining 58.3% of the variation (where creosote bush relative cover and soil pH are significant factors, their relationship is inverse to the dependent variable; see Table 7). Number of species is most closely linked to annual biomass, with an adjusted r^2 value of

.602. Perennial species richness, the best predictor of spring birds, is also a good predictor of fall birds (adjusted r^2 of .408 for number of sightings and .570 for number of species). However, the usefulness of the non-measured variables to predict fall birds falls far short of spring levels. There is no significant relationship between fall bird abundance and any non-measured variable, while the best regressor for numbers of species is topographic heterogeneity (adjusted r^2 of .208). Multiple regression did not yield statistically significant results. As in the spring, there is no relationship between soil pH and permeability and fall bird abundance or diversity.

B3. Creosote Bush Habitats

Within creosote habitats, perennial species richness was again the best predictive factor in determining bird numbers (adjusted $r^2 = .618$) and number of species (adjusted $r^2 = .630$; see Table 7). In addition, creosote bush relative cover and soil pH are nearly as good at predicting both numbers of sightings (creosote rel. cover adj. $r^2 = .618$; pH adj. $r^2 = .607$) and species (creosote rel. cover adj. $r^2 = .615$; pH adj. $r^2 = .618$). This is unusual; for most comparisons, creosote bush relative cover and soil pH have little to no value in predicting bird numbers. For non-measured variables, total ranking and topographic heterogeneity were best predictors of birds in creosote habitats (total ranking adj. $r^2 = .225$ for no. ind., r^2 for no. sp. $= .364$; topo. hetero. adj. $r^2 = .263$ for no. ind. and .355 for no. sp.). Multiple regression for number of species using perch availability and topographic heterogeneity increases the adjusted r^2 to .437 [$F(2,66) = 26.663$; $p < .01$].

C. Topography

Topography is a highly significant factor in determining both the number of sightings [$F(4,98) = 5.553$; $p = .0005$] and the number of species [$F(4,98) = 9.659$; $p = .0001$]. Mountainous transects had more sightings and species than all other topographies. The more limited topographic relief present in creosote bush habitats (bajada and outcrop) was also a significant factor influencing the number of sightings [$F(1,63) = 11.238$; $p = .0014$] and the number of species [$F(1,63) = 4.52$; $p = .0374$]. In an attempt to delineate this relationship more clearly, elevation and distance to water were examined in relation to bird number and diversity. Elevation is a highly significant factor influencing both bird and species number, with the sole exception of bird numbers in the fall. It does not, however, have the predictive power of the vegetative measures. Distance to water does not correlate significantly with either bird abundance or species diversity. As mentioned above, topographic heterogeneity has good predictive value for numbers of sightings and species.

D. Level of Disturbance

Two transects, Bitter Springs Disturbed Creosote and Bitter Springs Dune, were considered to be highly disturbed, while the others were classified as low disturbance. Highly significant differences were seen when comparing the high disturbance to the low disturbance transects, both in numbers of sightings [$F(1,104) = 8.313$; $p = .0048$] and in numbers of species [$F(1,104) = 8.285$; $p = .0049$]. There were also significant differences between the Bitter Springs Disturbed Creosote transect and the other creosote bush transects, both in numbers of sightings [$F(1,63) = 6.019$; $p = .0169$] and in numbers of species [$F(1,63) = 8.873$; $p = .0041$]. Interestingly, there was significant interaction between disturbance and season in the numbers of sightings [$F(1,104) = 5.145$; $p = .0254$] and in the numbers of species [$F(1,104) = 4.258$; $p = .0416$]. The effect of disturbance is less in the fall than in the spring: there were no significant differences between high and low levels of disturbance in the fall. The amount pristine ranking, while often significant, has little power to predict bird abundance and diversity.

E. Individual Species

How well do individual species fit with the more general picture created when looking at numbers of sightings and species? In order to address this question, the four most abundant species: Sage Sparrow, Black-throated Sparrow, Horned Lark, and Raven, were looked at individually. While ANOVA of creosote bush vs. non-creosote bush habitats showed no significant differences between them for these four species, regression analysis of creosote bush habitats showed enough differences to warrant further examination.

E1. Sage Sparrows

The distribution of Sage Sparrows is affected by season, habitat, and topography. Sage Sparrows were 10% of spring sightings and 53% of fall sightings, a significant difference between the two [$F(1,107)=4.401$; $p=.0383$]. Habitat choice also showed significant differences, with saltbush being the preferred habitat [$F(5,96)=4.070$; $p=.0021$]. Two-factor ANOVA of topography and season showed them both to be significant and to interact. In the spring, Sage Sparrows prefer playa, whereas in the fall, dune, rocky outcrops, and playa are about equally selected, and all areas except playa have increased numbers of Sage Sparrows. In creosote bush habitats, there are also significant effects of topography, season, and interaction [$F(1,63)=5.146$; $p=.0267$ for topography, $F(1,63)=9.559$; $p=.0030$ for season, and $F(1,63)=9.504$; $p=.0030$ for interaction]. While there is no difference in Sage Sparrow abundance in bajadas from spring to fall, rocky outcrops show a large increase in fall numbers. There were no significant differences in Sage Sparrow numbers between highly disturbed and lightly disturbed habitats.

The power of measured and non-measured variables to predict Sage Sparrow abundance is much lower than it is for numbers of sightings and species (Table 8). A negative relationship to creosote bush relative cover is the best predictor for spring, fall, and creosote bush habitats (spring adj. $r^2=.178$; fall adj. $r2=.311$, and creosote adj. $r^2=.387$), explaining at most about 39 percent of the variation. Soil pH (also an inverse relationship) is an equally good predictor of creosote bush habitat Sage Sparrow numbers (adj. $r^2=.387$). Non-measured variables show an even weaker connection. In spring, a lack of topographic heterogeneity is the best predictor of Sage Sparrow abundance (adj. $r^2=.111$), no variables are significant in the fall, and the absence of perch availability is the only significant predictor in creosote bush (adj. $r^2=.074$). Multiple regression increases the predictive power slightly: in spring, vegetation diversity and topographic heterogeneity combine to give an adjusted r^2 of .182 [$F(2,55)=7.108$; $p<.01$]. Vegetation diversity, amount pristine, and H_2O availability together give an adjusted r^2 for fall of .114 [$F(3,51)=3.179$; $p<.05$]. In creosote bush habitats, vegetation diversity and perch availability result in an adjusted r^2 of .145 [$F(2,66)=6.598$; $p<.01$].

E2. Black-throated Sparrows

Of the four species analyzed individually, Black-throated Sparrows are the closest to the general pattern for number of sightings and species. The abundance of Black-throated Sparrows varied significantly with season [$F(1,107)=25.13$; $p=.0001$], accounting for 29% of all sightings in the spring, but only 3% in the fall. Because of the scarcity of fall sightings, no fall analysis was done for Black-throated Sparrows. Disturbance, habitat and topography showed significant differences [$F(1,107)=4.815$; $p=.0304$ for dist., $F(5,107)=2.891$; $p=.0175$ for habitat, and $F(4,107)=5.751$; $p=.0003$ for topography]. Black-throated Sparrows preferred lightly disturbed areas; blackbush scrub and mixed desert scrub habitats were preferred to creosote bush scrub, and saltbush scrub, alkali scrub, and dune had low levels of birds. Topographically, mountain and rocky outcrops have the most Black-throated Sparrows, bajada and playa have medium-to-low densities, and none was found in the dune.

Most measured and non-measured variables were significant when regressed against spring Black-throated Sparrow numbers (Table 8). Annual species richness and annual biomass were the best predictors of Black-throated Sparrow abundance (adj. $r^2=.651$ for ann. sp. rich.; $r^2=.653$ for ann. biomass). For non-measured variables, topographic heterogeneity was the best predictor (adj. $r^2=.408$). In creosote bush habitats, perennial species richness is the best measured variable for predicting Black-throated Sparrow numbers (adj. $r^2=.358$), while topographic heterogeneity is again the best non-measured variable (adj. $r^2=.325$). Multiple regression did not yield statistically significant results.

E3. Horned Lark

Horned Larks were seen only during the spring, with 16% of spring sightings [a highly significant difference between seasons: $F(1,107)=8.61$; $p=.0041$]. Therefore, only spring and spring creosote bush habitat analyses were done. While ANOVA showed differences between all transects and between creosote bush transects [$F(12,82)=3.045$; $p=.0014$ for all transects; $F(7,51)=2.951$; $p=.0113$ for creosote transects], there were no differences seen between levels of disturbance, habitat types, or topographies. Even though no Horned Larks were seen in the mountain areas, there was enough variation in the other topographies to keep this from being a significant result.

No measured variables were significant in determining Horned Lark abundance in the spring (Table 9). In creosote habitats, annual species richness and annual biomass (adj. $r^2=.339$ for both annual measures) were equally good predictors of abundance. For non-measured variables, only amount pristine had a significant relationship to Horned Lark (adj. $r^2=.059$ for spring and adj. $r^2=.098$ for creosote). Multiple regression for spring observations using vegetation diversity and amount pristine together increase the adjusted r^2 to .11 [$F(2,55)=4.383$; $p<.05$]. Multiple regression analysis for creosote bush habitats did not give statistically significant results.

E4. Raven

Raven presence did not differ between spring and fall, with 7% and 9% of sightings, respectively [$F(1,107)=2.471$; $p=.119$]. Significant differences occurred between transects [$F(12,82)=1.900$; $p=.0461$], however, there was no difference between levels of disturbance, habitats, or topographies. In creosote habitats, Ravens showed a significant preference for rocky outcrops over bajadas [$F(1,63)=6.452$; $p=.0136$]. A summary of Raven sightings for walking and driving transects is given in Appendix C.

The only measured variable found to be significant when regressed against total Raven numbers is creosote bush relative cover (adj. $r^2=.09$; see Table 9). In creosote bush habitats, perennial species richness and soil pH are the best predictors of abundance (adj. $r^2 = .204$ for per. sp. rich.; adj. $r^2 = .199$ for pH). For non-measured variables, none is significant for the total data, and topographic heterogeneity is the best predictor for creosote bush habitats (adj. $r^2 = .152$). Multiple regression for total data using perch availability and topographic heterogeneity gives an adjusted r^2 of .054 [$F(2,107) = 4.059$; $p < .05$]. Multiple regression analysis for creosote bush habitats did not give statistically significant results.

3.2 DRIVING TRANSECTS

A total of 437 birds of 29 species were seen during twelve iterations of the three driving transects (see Appendix B for driving transect summary). 320 (73%) of the sightings were in the spring and 117 (27%) were in the fall (because each transect was monitored four times during the year, a sighting may not represent a unique individual). Of the 29 species seen, 24 (83%) were seen in the spring and 13 (45%) were seen in the fall (the number of species is not additive; eight species are shared between the spring and the fall). The number of sightings seen is correlated with the number of species [$r(10\ df) = .603$; $p < .05$]. For the year as a whole, four species were responsible for 74% of all sightings and nine species were responsible for 90% of all sightings (Figure 1). Compared to walking transects, in driving transects the same number of species constitutes a greater proportion of sightings, indicating that driving transect results are lower in diversity. In the spring, three species accounted for 74% of sightings, and four species yielded 76% of all sightings in the fall (Figure 6).

Two-factor ANOVA showed highly significant differences between transects [$F(2,6) = 24.51$; $p = .0013$] and seasons [$F(1,6) = 62.91$; $p = .0002$] for numbers of sightings, and strong interaction between transect and season [$F(2,6) = 15.46$; $p = .0043$]. Analysis of Variance for numbers of species also showed significant differences between transect [$F(2,6) = 9.03$; $p = .0155$] and season [$F(1,6) = 17.79$; $p = .0056$], but no significant level of interaction between transect and season [$F(2,6) = 4.13$; $p = .0744$]. Figure 7 shows bar charts of relative frequency of sightings and species by transect and season. Transect order ranked by numbers of sightings and species is different between sightings and species, and between seasons.

There were no vegetation measures to use in regression analysis against numbers of sightings or species found on driving transects. Therefore, the same non-measured transect ranking system used for analyzing walking transects was used for driving transects (see Materials and Methods and Table 5 for an explanation of transect ranking, see Table 10 for results). The only significant predictor of bird abundance in the spring was perch availability (adj. $r^2 = .907$), whereas in the fall the best predictor was vegetation diversity (adj. $r^2 = .864$). For numbers of species in the spring, topographic heterogeneity and H_2O availability were equally good predictors (adj. $r^2 = .929$ for both), and no variable was significant in the fall.

For individual species (Horned Lark, Raven, Black-throated Sparrow, and Red-tailed Hawk), no significant differences were seen between seasons according to ANOVA. For Black-throated Sparrow, there was no significant difference between seasons even though there were no Black-throated Sparrows sighted in the fall, indicating that small sample size is a problem. Regression analysis for Black-throated Sparrows against rankings showed no significant level of association between the two (see Table 11). Horned Lark numbers were best predicted by the amount of pristine habitat (a negative relationship; adj. $r^2=.417$). This finding is in contrast to that for walking transects, where pristine habitat has a small, but positive relationship to Horned Lark numbers. Red-tailed Hawks are best predicted by perch availability (adj. $r^2=.321$). As in the walking transects, Raven abundance is best predicted by topographic heterogeneity and H_2O availability, (adj. $r^2=.397$ for both). ANOVA was used to compare sightings per kilometer and maximum group size between walking and driving transects (see Appendix C). Results show driving transects to be indistinguishable from walking transects in Raven sightings per kilometer, but significantly different in group size [$F(1,15)=20.684$, $p<.05$ for spring, and $F(1,15)=17.476$, $p<.05$ for fall]. An examination of all raptor nests on driving transect routes and elsewhere on Fort Irwin failed to reveal any Desert Tortoise remains.

3.3 SPOT BIRDING

Natural and artificial wetlands have the highest concentrations of birds and the highest bird diversity of any habitats at Fort Irwin. A total of 138 species were seen during spring and fall spot birding (see Appendix C for Fort Irwin Bird List). Four of these are introduced species. In all, 38 families representing 15 orders were recorded. Wetlands are heavily used by migrant species. Two State Threatened species were seen: Swainson's Hawk and California Black Rail. There were 16 species seen at Fort Irwin in 1994 that are listed by California Department of Fish and Game as "Species of Special Concern." They are: Northern Harrier, Sharp-shinned Hawk, Cooper's Hawk, Golden Eagle, Prairie Falcon, California Gull, Burrowing Owl, Long-eared Owl, Vaux's Swift, Bendire's Thrasher, Crissal Thrasher, LeConte's Thrasher, Black-tailed Gnatcatcher, Loggerhead Shrike, Gray Vireo, Virginia's Warbler, and Yellow Warbler. California Department of Fish and Game "Special Animals" includes all of the above and Great Egret.

4. DISCUSSION

1994 was not a good year for birds. Rainfall was extremely low, 2.8 cm for the period from 5/93-5/94 as measured at Bicycle Lake, and 5.5 cm as measured at Goldstone (compare to 23.2 cm at Bicycle Lake and 27.3 cm at Goldstone for the same period in 1992-1993; NOAA, 1992-1994). Annual biomass was zero on many transects. While many singing males were recorded on transects and in birding spots, there was little evidence that breeding took place. No active nests were seen, and juveniles were recorded only on the Avawatz Creosote transect. This is not surprising for desert habitats. A study conducted in the northern Mojave Desert in Nevada found that three out of five species studied bred only once in three years (Hill, 1980).

When looking at the distribution of birds in walking and driving transects, large differences were found between transects, seasons, habitats, topographies, and levels of disturbance. Twice the number of birds and species were seen in the spring as compared to the fall. Mountainous transects, especially blackbush habitat, had the highest bird numbers and diversity. Creosote bush habitats have fewer numbers of birds and species than do non-creosote habitats. Heavily disturbed transects have lower abundance and diversity than lightly disturbed or undisturbed ones.

An attempt to link measured and non-measured parameters to birds via regression analysis met with varying levels of success. The more general measures of numbers of individual and species could be predicted quite well (about 60 to 80 percent) from vegetation measurements. Non-measured variables could predict from about 20 to 50 percent of variation. Linkage is tighter in the spring than in the fall. Bird abundance and diversity in creosote bush habitats showed some special linkage to creosote bush relative cover and soil pH, both negative relationships. When the variables were applied to individual species, however, their predictive power waned. Black-throated Sparrow numbers were best predicted by these measures, their values falling in the same range as for sightings and species. Linkage for Sage Sparrows, Horned Lark, and Raven was quite weak (in the 9 to 40 percent range) for measured variables, and even weaker for unmeasured variables (6 to 15 percent).

Why are some groups tightly linked to measured variables and others not? Other work is divided about whether vegetation measures are useful in predicting bird abundance and diversity (for example, see Austin, 1970, Maurer, 1986, Mills, et. al., 1991). One reason is that many species do not fit the general picture shown when looking at numbers of sightings and species. At Fort Irwin, vegetation measures are highly correlated to elevation, with the highest diversity and plant cover in the mountains. Migrants are found primarily in springs (not covered by this approach) and mountain areas, which cause numbers of sightings and species to be heavily weighted towards higher elevations. Migrants have no need to establish breeding territories and find suitable nest sites, so are free to congregate in areas containing the most food and shelter.

Black-throated Sparrows (which fit vegetation measures well) were found at all elevations at Fort Irwin, and other research (Vander Wall and MacMahon, 1984) showed Black-throated Sparrow abundance to be highly correlated to shrub foliage volume. Sage Sparrows and Horned Lark, on the other hand, are not found in the mountains, so the linkage to general vegetation measures is limited. Sage Sparrows and Horned Lark have specific habitat preferences which do not conform to general measures of vegetation richness and density. Bock and Webb (1984) found that the best predictor of Horned Lark densities was a low percentage of shrub cover, and other work (Wiens and Rotenberry, 1985, Medin, 1986) demonstrated that Horned Lark numbers increased with disturbance.

At least in the northern part of their range, Sage Sparrows are closely associated with sagebrush (*Artemisia sp.*). They are territorial and evidently show site tenacity, keeping numbers fairly even during large changes in environmental conditions (Wiens and Rotenberry, 1985). Sage Sparrows at Fort Irwin are found primarily in saltbush flats in which *Artemisia spinescens* is a characteristic Mojave Desert saltbush habitat component (Vasek and Barbour, 1995). Studies concerning nest site selection found Sage Sparrows nesting exclusively in sagebrush (Rich, 1980, Reynolds, 1981, and Peterson and Best, 1985). In a study of birds with specific nesting preferences (Tomoff, 1974), the density of nesting birds correlated significantly with the density of nest substrate shrubs. More work is needed to determine Sage Sparrow habitat preference at Fort Irwin.

Ravens are of special concern because they are pests in some circumstances, and are known to prey on juvenile Desert Tortoises (*Gopherus agassizii*, BLM, 1990). Raven populations in the Mojave Desert have increased over 1500 percent in the years from 1968-1988 (BLM, 1990). The reasons for this are thought to be increased food availability and perch sites provided by humans. Ravens use power lines for perch and nest sites disproportionately often relative to their availability, and are more common along transmission power lines and paved highways than in control areas (Knight and Kawashima, 1993). A comparison of Raven numbers in different land use areas found them to be significantly more common in urban-suburban and irrigated farmland than in rangeland or a control area (Knight et. al., 1993). Sanitary landfills and sewage treatment plants attract and maintain large numbers of Ravens (BLM, 1990). At Fort Irwin there are several areas of concern. Power transmission lines run extremely close to the Fort Irwin Study Site (FISS) and right through an area of high Desert Tortoise concentration. Raven predation on Tortoises has been documented at FISS (D. Morafka, pers. comm.). Tortoises also occur at other locations at Fort Irwin. Fort Irwin has large numbers of Ravens associated with the cantonment area, and Ravens scavenge battlefields (pers. obs.). Where Raven concentrations occur near Tortoise populations, particularly where there are good perch sites, there is a risk of tortoise predation. In addition, Raven associated damage to property in the cantonment may be a problem.

Three different survey methods were used in this study. Walking transects yielded the most useful data because of the addition of vegetation data and because there were more repetitions, giving more statistical power. Spot birding gave by far the highest species diversity and is essential for diversity studies. Late contract award prevented more spot birding from being done. Driving Transects were the least useful because habitat was variable, there were no vegetation measures, results are skewed to favor raptorial birds, and small sample size limited statistical usefulness.

5. RECOMMENDATIONS

1. **Protect mountainous areas, especially washes and high bajadas which are accessible to vehicles.** Outside of wetlands, mountains have the highest concentration and diversity of both resident and migrant birds. Fortunately, mountains at Fort Irwin have been lightly used for training and have little degradation. However, richly vegetated high bajadas and washes show a fair amount of disturbance and have no protection. Between the fall of 1994 and the spring of 1995, there was evidence of recent disturbance on the Avawatz Creosote grid. The tracks were of one or two isolated vehicles which ran over densely vegetated land. There was no evidence that maneuvers had been executed in the immediate area and it was concluded that this was an example of "joy riding" seen many places on the base. In one unprotected wash in the Avawatz, dozens of Desert Willow (*Chilopsis linearis*) were found, which support hummingbirds and others. The richness of these areas and their low utility for training leads to a strong recommendation for their protection.

2. **Continue to protect springs, expanding protection to include a 500m buffer zone and 1000m of wash.** Bird densities in Arizona Sonoran desert scrub were significantly higher at the riparian edge and in the first 500m outside the riparian zone than in the second 500m or in upland desert (Szaro and Jackle, 1985). In addition, washes within 1000m of riparian areas had an increased breeding bird density. Native riparian plants such as mesquite are especially valuable to indigenous breeding birds. Bitter Springs has much unprotected riparian habitat, and joy riders still violate Bitter Springs boundaries. More protection is needed for spring areas.

3. **Increase protection of all off-limits areas and provide access for foot traffic.** Signs and fences around off-limits areas need renewal, and penalties should be instituted for vehicle violation of these areas. Building of styles (passages for foot traffic only) would greatly increase safety of access for researchers.

4. **Curb unnecessary off-road vehicle activity.** Fort Irwin has a policy that all vehicles shall stay on existing roads and trails, yet there is daily evidence that this rule is not taken seriously. Road proliferation is a serious problem, and joy riding is inexcusable. Eliminating all unnecessary vehicle activity would tremendously benefit the biota at Fort Irwin. Increased supervision and effective deterrent measures are needed to effect this change.

5. **Protect and enhance artificial wetlands.** Artificial wetlands provide habitat for migrating and resident water birds. These types of habitats are in increasingly short supply because human water use in the desert has decreased the extent of natural wetlands (G. Sawyer, pers. comm.). Birds depend on the availability of these artificial wetlands. In addition, the enhancement of these areas for human enjoyment would be a tremendous educational and psychological benefit to the residents

of Fort Irwin and the greater Barstow area. Specifically, the establishment of a birding program in collaboration with the local Audubon Society, the building of walkways and piers to increase observer access, the enhancement of bird nesting and roosting habitat with native plantings, and the removal of *Tamarix sp.* from the area are recommended.

6. **Monitor Raven nest and perch sites for Tortoise remains.**

7. **Continue walking transects, and continue vegetation monitoring.**

8. **Continue spot birding.**

9. **Evaluate driving transects for future use.**

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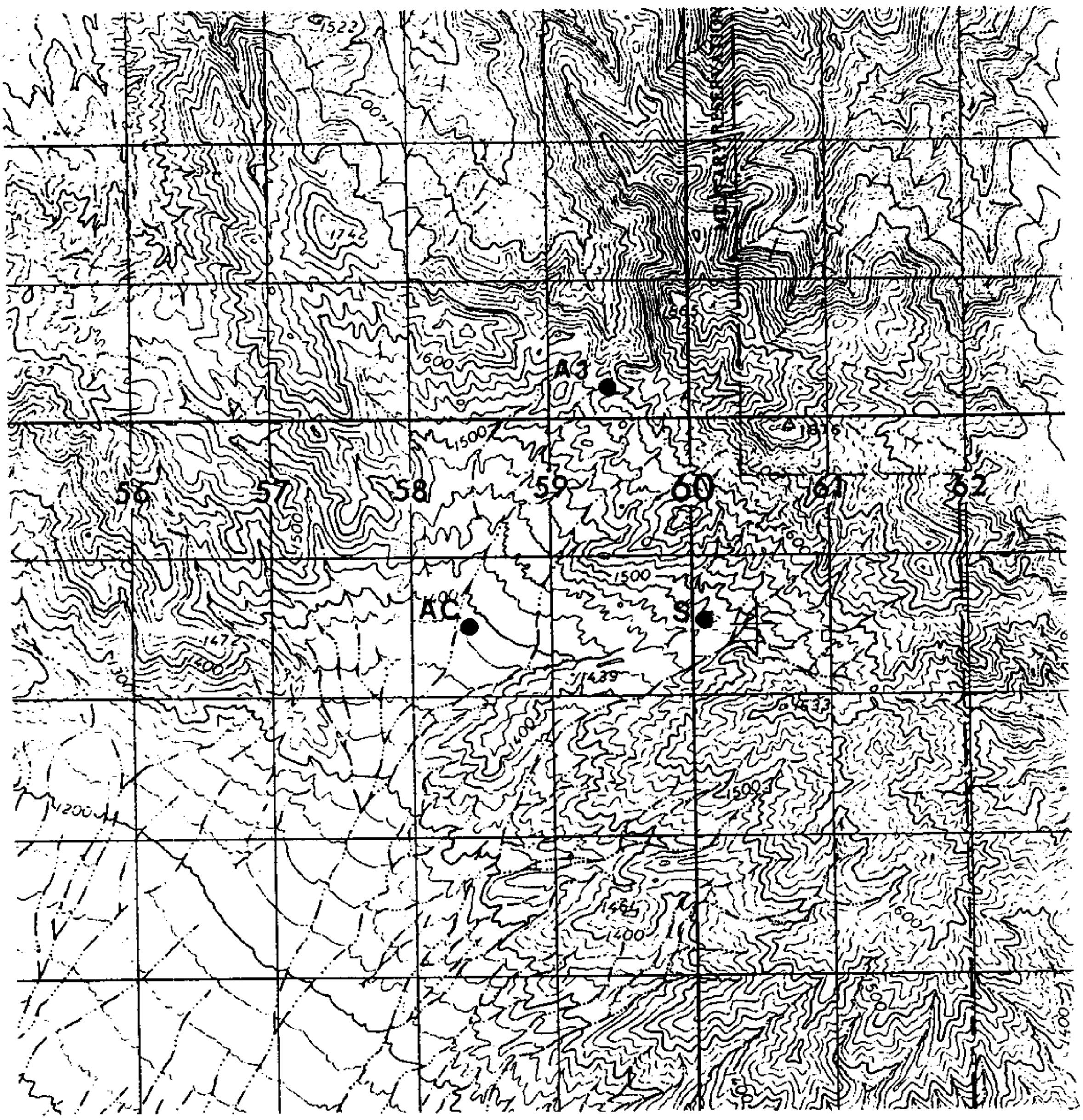
MAPS

MAP 1

AVAWATZ CREOSOTE, AVAWATZ JUNIPER, AND AVAWATZ SPOT BIRDING

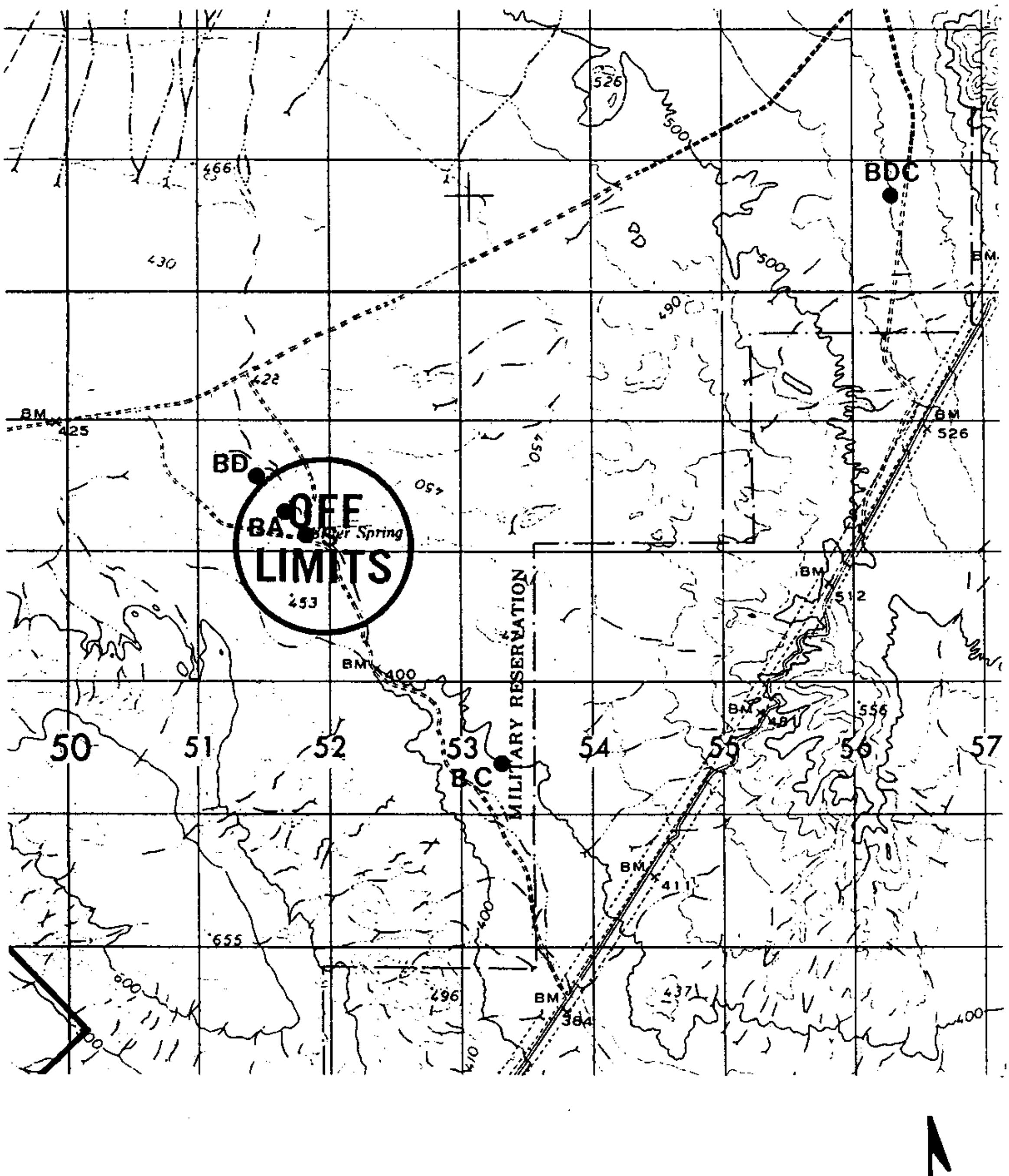


2cm=1km

N

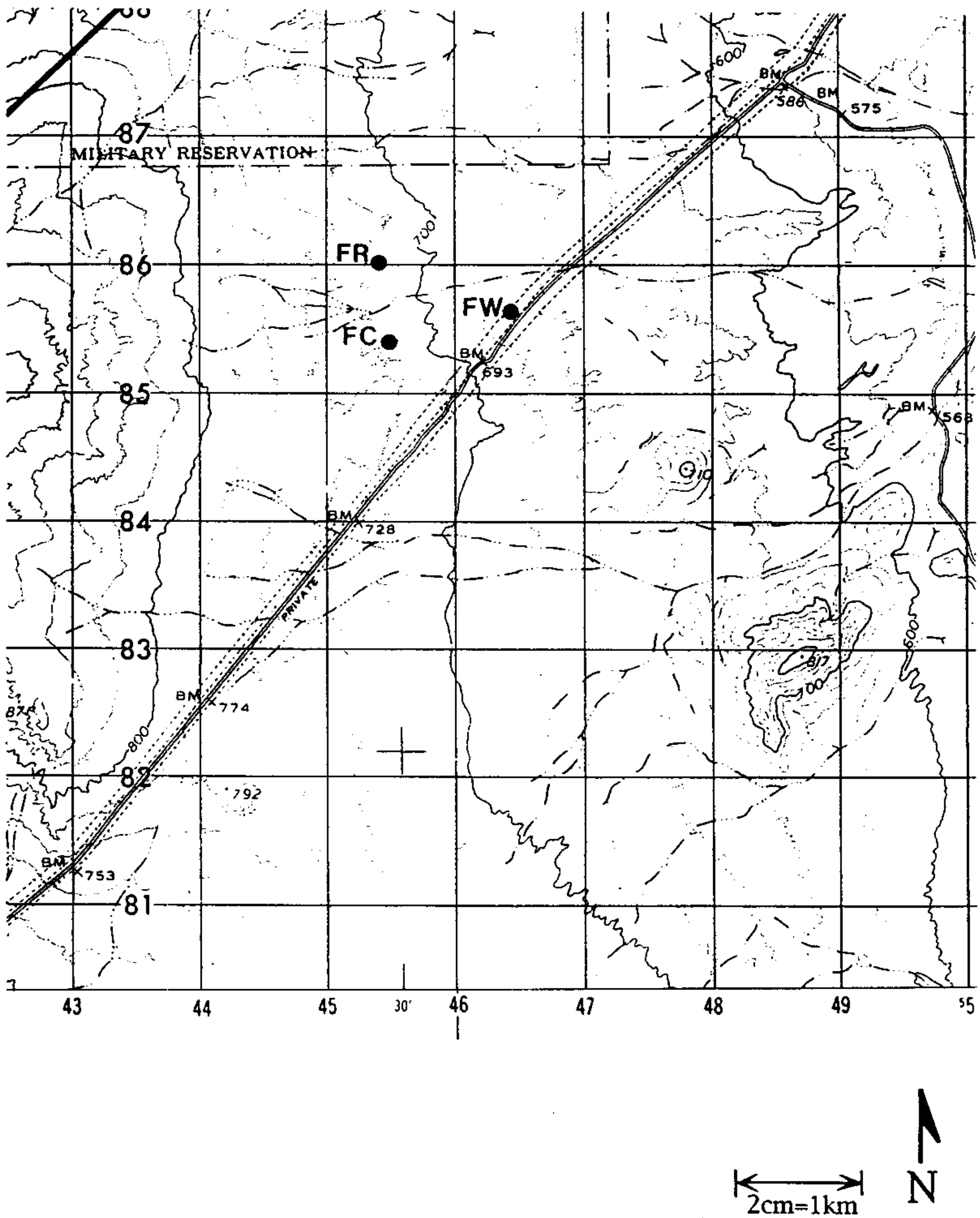
MAP 2

BITTER SPRINGS ALKALI, BITTER SPRINGS CREOSOTE, BITTER SPRINGS DUNE, BITTER SPRINGS DISTURBED CREOSOTE, AND BITTER SPRINGS SPOT BIRDING



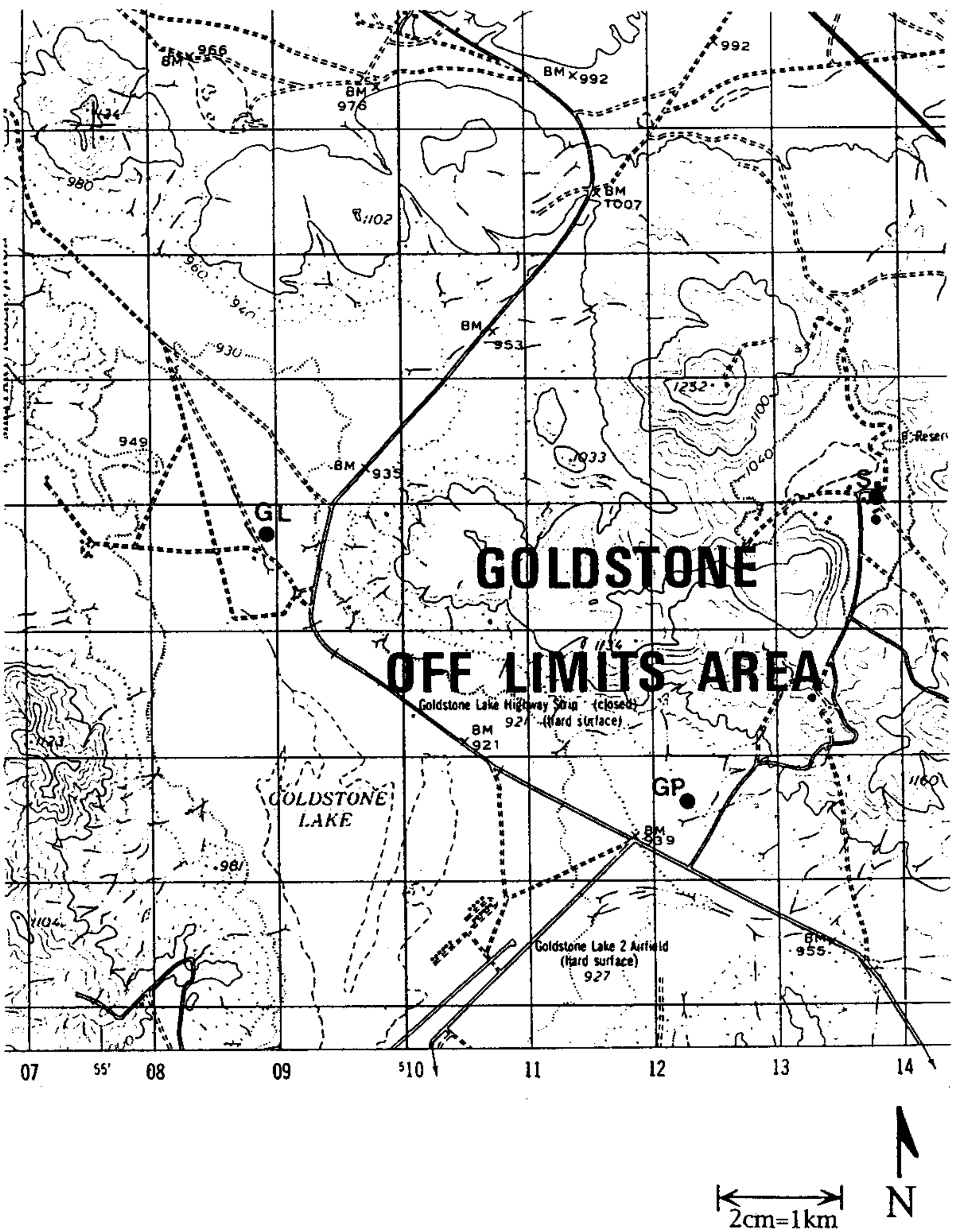
MAP 3

FISS CREOSOTE, FISS ROCK, AND FISS WASH



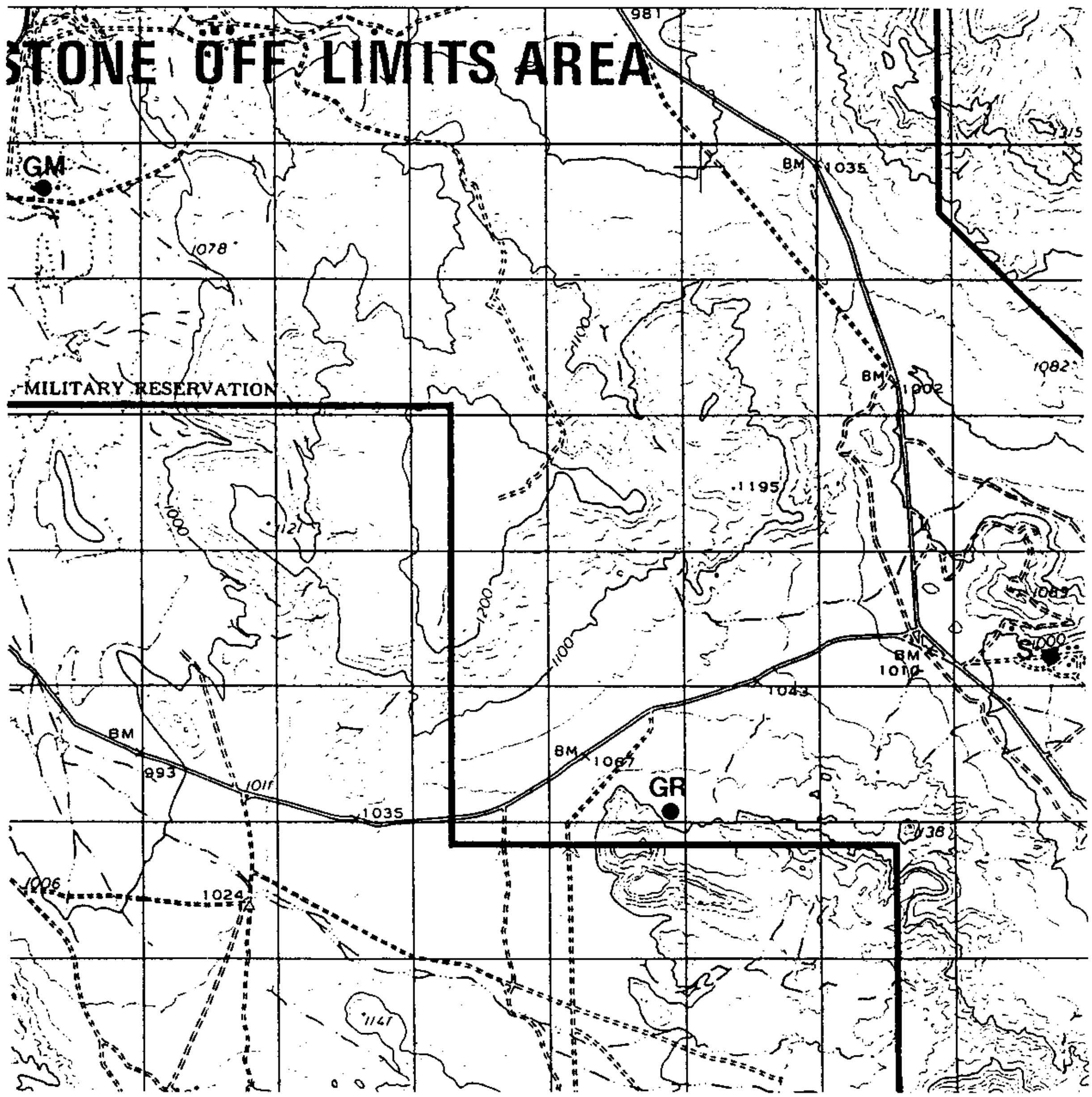
MAP 4

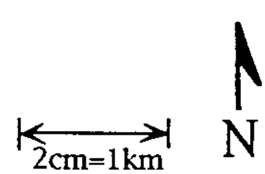
GOLDSTONE LAKE, GOLDSTONE PIONEER, AND PIONEER STATION SPOT BIRDING



MAP 5

GOLDSTONE MOJAVE, GOLDSTONE ROCK, AND ECHO STATION SPOT BIRDING



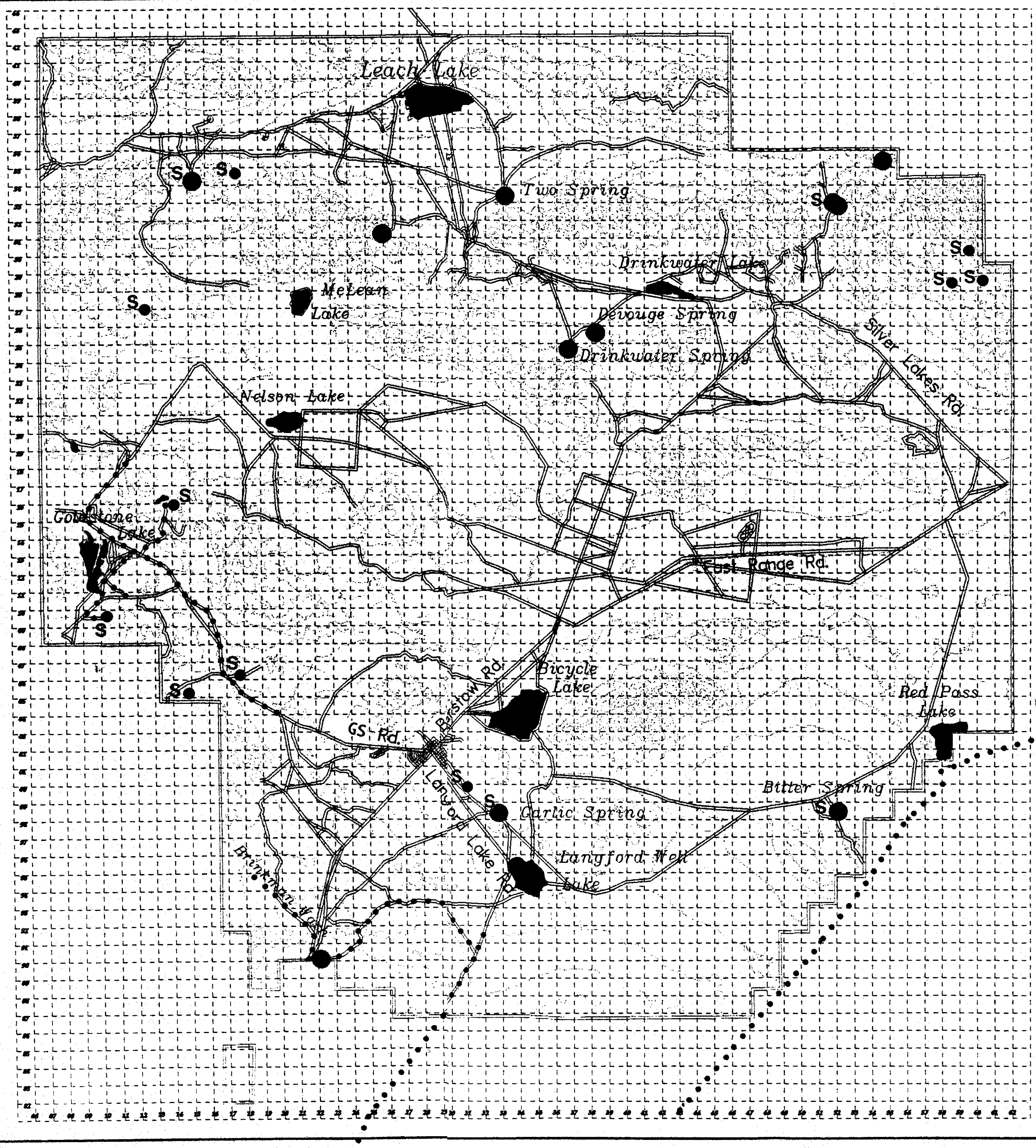


MAP 6

DRIVING TRANSECTS AND SPOT BIRDING

Fort Irwin

NTC



LEGEND

- *ROAD*
- *WASH*
- *SPRINGS*
- *DRY LAKEBED*
- • • • Driving Transect
- ●S Spot Birding

TABLES

Table 1. Relation of Bird Walking Transects to Other Studies

Bird Transect	Vegetation Transect (Ferrus-Garcia, 1995)	Correspondence to:		
		Reptiles	Mammals	Soils
Avawatz Creosote	Avawatz Mtns. Mixed Desert Scrub (AMMDS), transect A & B	Avawatz creosote	Avcre	Fan Remnant Site, Avawatz Mtns Area
Avawatz Juniper	Avawatz Mtns. Blackbush Scrub (AMBS), transects A-D	Avawatz juniper	None	Mountain Sideslope and Drainageway Sites, Avawatz Mtns Area
BS Alkali	None	Bitter Springs alkali	BSalk	Alkali Flat Site, Bitter Springs Area
BS Creosote	Bitter Springs Creosote Bush Scrub (BSCBS), transects A & B	Bitter Springs alluvium	BScre	Undisturbed Alluvial Fan Site, Bitter Springs Area
BS Disturbed Creosote	Soda Mtns. Creosote Bush Scrub Disturbed (SMCBSD), transects A & B	Bitter springs disturbed alluvium	BSdcre	Disturbed Creosote Site, Red Pass/Soda Mtns Area
BS Dune	None	Bitter Springs dune	BSdun	Dune Site, Bitter Springs Area
FISS Creosote	None	FISS alluvium	None	None
FISS Rock	None	FISS rock	None	None
FISS Wash	None	FISS wash	None	None
GS Echo Rock	None	None	None	None
GS Mojave	Goldstone Mixed Creosote Bush Scrub (GMxCBS), transects A & B	H1T5	Mocre	Mixed Alluvial Fan Site, Goldstone Area
GS Pioneer	Goldstone Volcanic Creosote Bush Scrub (GVCBS), transect A	None	Pion	Volcanic Fan Site, Goldstone Area
GS Lake	Goldstone Lake Saltbush Scrub (GLSS), transect A	H1T1	Lake	Alluvial Flat Site, Goldstone Lake Area

Sources: Brown and Nagy, 1995; Burlingame, 1994; Morafka, 1993; Recht, 19941) Mammals: Recht, Michael A. 1994.

Table 2. Transect Visitation Dates and Location

Driving Transects						
Transect Name	Dates Visited				UTM Start	UTM End
Powerline Road	4/15/94	4/16/94	11/9/94	11/10/94	543259E, 3881706N	543259E, 3902510N
Goldstone	4/13/94	4/14/94	11/4/94	11/11/94	518832E, 3904614N	511438E, 3918585N
Manix Trail	4/22/94	4/23/94	11/1/94	11/2/94	Manix trail 9 mi. south of 3890N	518308E, 389471N

Walking Transects										
Transect Name	Dates Visited									UTM Start
BS Alkali	4/27/94	4/28/94	4/29/94	4/30/94	10/28/94	10/30/94	10/31/94	11/3/94		551670E, 3898270N
BS Dune	4/27/94	4/28/94	4/29/94	4/30/94	10/28/94	10/30/94	10/31/94	11/3/94		551500E, 3896480N
BS Creosote	4/25/94	5/1/94	5/2/94	6/1/94	10/30/94	10/31/94	11/3/94	11/5/94		553415E, 3898457N
BS Dist. Creosote	4/25/94	5/1/94	5/2/94	6/1/94	10/28/94	10/30/94	10/31/94	11/3/94		556379E, 3900751N
GS Mojave	4/17/94	4/18/94	4/19/94	4/20/94	5/18/94	10/20/94	10/21/94	10/22/94	10/23/94	510281E, 3909884N
GS Pioneer	4/17/94	4/18/94	4/19/94	4/20/94	5/19/94	10/20/94	10/21/94	10/22/94	10/23/94	512253E, 3913688N
GS Echo Rock	4/17/94	4/18/94	4/19/94	4/20/94	5/17/94	10/20/94	10/21/94	10/22/94	10/23/94	514938E, 3905104N
GS Lake	4/17/94	4/18/94	4/19/94	4/20/94	5/20/94	10/20/94	10/21/94	10/22/94	10/23/94	508922E, 3915759N
FISS Wash	5/8/94	5/9/94	5/10/94	5/11/94	11/5/94	11/6/94	11/7/94	11/8/94		546430E, 3885600N
FISS Creosote	5/8/94	5/9/94	5/1094	5/11/94	11/5/94	11/6/94	11/7/94	11/8/94		545490E, 3885420N
FISS Rock	5/8/94	5/9/94	5/10/94	5/11/94	11/5/94	11/6/94	11/7/94	11/8/94		545410E, 3886010N
Avawatz Creosote	5/3/94	5/4/94	5/5/94	5/6/94	10/24/94	10/25/94	10/26/94	10/27/94		558445E, 3928472N
Avawatz Juniper	5/3/94	5/4/94	5/5/94	5/6/94	10/24/94	10/25/94	10/26/94	10/27/94		559474E, 3930179N

Table 3. Spot Birding Locations

Location	Northing	Easting
Avawatz Mountains	3928472N	558445E
	3928580N	560740E
	3930179N	559474E
Bitter Springs	3898130N	551790E
Cave Springs	3932600N	551800E
Garlic Springs	3898360N	532750E
Goldstone Echo Station	3906190N	517850E
Goldstone Mojave Dish	3909884N	510281E
Goldstone Echo Rock	3905104N	514938E
Goldstone Pioneer Station	3915800N	513755E
Granite Mountains	392694N	512607E
Hellwind Canyon	3934050N	517750E
Leach Springs	3934640N	515250E
Settling Ponds	3899810N	530960E

Table 4. Walking Transect Classifications

Transect	Habitat Type	Topography	Disturbance
Avawatz Creosote (AC)	Mixed Desert Scrub	Bajada	Low
Avawatz Juniper (AJ)	Blackbush Scrub	Mountain	Low
Bitter Springs Alkali (BA)	Alkali Scrub	Bajada	Low
Bitter Springs Creosote (BC)	Creosote Bush Scrub	Bajada	Low
Bitter Springs Disturbed Creosote (BDC)	Creosote Bush Scrub	Bajada	High
Bitter Springs Dune (BSD)	Dune	Dune	High
FISS Creosote (FC)	Creosote Bush Scrub	Bajada	Low
FISS Rock (FR)	Creosote Bush Scrub	Outcrop	Low
FISS Wash (FW)	Creosote Bush Scrub	Bajada	Low
Goldstone Echo Rock (GR)	Creosote Bush scrub	Outcrop	Low
Goldstone Mojave (GM)	Creosote Bush scrub	Bajada	Low
Goldstone Pioneer (GP)	Creosote Bush Scrub	Bajada	Low
Goldstone Lake (GL)	Saltbush Scrub	Playa	Low

Table 5. Transect Rankings

	Walking Transects													Driving Transects		
	AC	AJ	BA	BC	BD	BDC	FC	FR	FW	GL	GM	GP	GR	GS	MX	PL
Amount Pristine	4	5	3	4	2	2	5	5	4	4	3	3.5	5	4	2	4
Vegetation Diversity	4	4	3	2	1	1	2.5	1	3	2	3	2	3	4	3	2
Water Availability	2	2	4	3	3.5	2	2	2	2	2	4	2	2.5	3	2	2
Perch Availability	4	4	3	2	2	2	3	3	2.5	1	4	3	3	3	2	5
Topographic Heterogeneity	4	5	3	2	2	2	3	3.5	3.5	1	3.5	2	4	4	2	2
TOTAL	18	20	16	13	10.5	9	15.5	14.4	15	10	17.5	12.5	17.5	18	11	15

Table 6. Vegetation Meausurements vs. Transect Rankings

	Perennial % Cover (5df)	Perennial Species Richness (5df)	Creosotem Rel. Cover (5df)	Annual Species Richness (4df)	Annual Biomass (4df)
Total Ranking	.919**	.866*	NS	.923**	.903**
Amount Pristine	NS	NS	NS	NS	NS
Vegetation Diversity	.965**	.944**	-.756*	.956**	.853*
H_2O Availability	NS	NS	NS	NS	NS
Perch Availability	.774*	NS	NS	.808*	.794*
Topographic Heterogeneity	.908**	.798*	NS	.921**	.936**
		Autocorrelation			
	Perennial % Cover (5df)	Perennial Species Richness (5df)	Creosote Rel. Cover (5df)	Annual Species Richness (4df)	Annual Biomass (4df)
Perennial % Cover	1				
Perennial Species Richness	.95**	1			
Creosote Bush Rel. Cover (-)	-.754*	-.865*	1		
Annual Species Richness	.993**	.959**	NS	1	
Annual Biomass	.945**	.838*	NS	.929**	1
Elevation	.937**	.924**	NS	.932**	.867*

Notes: * P<.05; ** P<.01; NS = Not statistically significant; See Section 2, "Materials and Methods" and Table 5 for explanation of Transect Rankings.

Table 7. Regression Analysis

Number of Sightings vs.	Spring	Fall	Creosote
Perennial % Cover	34.896; .530**	4.85; .125*	21.655; .385**
Perennial Species Richness	90.896; .748**	19.581; .408**	54.462; .618**
Creosote Bush Rel. Cover (-)	40.147; .566**	38.807; .583**	52.462; .618**
Annual Species Richness	70.839; .736**	13.383; .350**	13.417; .341**
Annual Biomass	45.303; .639**	12.216; .328**	13.417; .341**
Elevation	22.158; .278**	NS	9.826; .341**
Soil pH (-)	NS	NS	52.037; .607**
Soil Permeability	NS	NS	6.197; .136*
Total Ranking	32.832; 367**	NS	20.168; .225**
Amount Pristine	14.712; .200**	NS	7.725; .092**
Vegetation Diversity	26.652; .318**	NS	NS
H2O Availability	NS	NS	NS
Perch Availability	14.558; .198**	NS	15.837; .184**
Topographic Heterogeneity	25.147; .305**	NS	25.591; .263**
Number of Species vs.			
Perennial % Cover	44.595; .592**	12.961; .307**	22.202; .391**
Perennial Species Richness	106.71; .779**	36.775; .570**	57.165; .630**
Creosote Bush Rel. Cover (-)	25.794; .452**	20.883; .424**	53.671; .615**
Annual Species Richness	95.36; .791**	31.394; .569**	9.978; .272**
Annual Biomass	73.729; .744**	35.84; .602*	9.978; .272**
Elevation	28.345; .332**	17.862; .248**	20.832; .231**
Soil pH (-)	NS	NS	54.337; .618**
Soil Permeability	NS	NS	5.907; .129*
Total Ranking	55.757; .499**	14.286; .207**	38.795; .364**
Amount Pristine	7.295; .103**	NS	NS
Vegetation Diversity	49.804; .470**	10.826; .156**	16.983; .195**
H_2O Availability	NS	NS	7.852; .094**
Perch Availability	28.025; .329**	10.826; .162**	34.363; .336*
Topographic Heterogeneity	43.275.435**	14.441.208**	37.327;.355**

Numbers denote F; adj. R^2, * = $p<.05$, ** = $p<.01$; NS = Not statistically significant. Degrees of Freedom for regression anaylsis = (1),(N-2). N (number of cases) is as follows:

1. Soil pH and permeability a) spring = 39, b) fall = 36, c) creosote = 34;
2. Annual species richness and annual biomass a) spring = 26, b) fall = 24, c) creosote = 25;
3. Perennial percent cover, perennial species richness, and creosote bush relative cover a) spring = 31, fall = 28, c) creosote = 34;
4. All other variables a) spring = 56, b) fall = 52, and c) creosote = 67.

Table 8. Regression Analysis

Number of Sage Sparrows vs. Measured Variables	Spring	Fall	Creosote
Perennial % Cover	NS	NS	7.275; .160*
Perennial Species Richness	NS	NS	18.281; .344**
Creosote Bush Rel. Cover (-)	7.509; .178**	13.167; .311**	20.333; .387**
Annual Species Richness	NS	NS	NS
Annual Biomass	NS	NS	NS
Elevation	NS	NS	NS
Soil pH (-)	NS	NS	21.836; .387**
Soil Permeability	NS	NS	4.423; .094*
Non-Measured Variables			
Total Ranking	NS	NS	NS
Amount Pristine	NS	NS	NS
Vegetation Diversity	NS	NS	NS
H2O Availability	NS	NS	NS
Perch Availability (-)	6.01; .083*	NS	6.239; .074**
Topographic Heterogeneity (-)	7.856; .111**	NS	NS
Number of Black-Throated Sparrows vs. Measured Variables	**Spring**	**Spring Creosote**	
Perennial % Cover	28.799; .481**	6.451; .243*	
Perennial Dpecies Richness	37.966; .552**	10.482; .358**	
Creosote bush Rel. Cover (-)	8.022; .190**	9.405; .331**	
Annual Species Richness	47.672; .651	NS	
Annual Biomass	48.123; .653**	NS	
Elevation	35.419; .385**	17.932; .332	
Soil pH (-)	8.72; .169**	8.937; .318**	
Soil Permeability	NS	NS	
Non-Measured Variables			
Total Ranking	37.218; .397**	16.386; .312**	
Amount Pristine	16.794; .223**	6.063; .13*	
Vegetation Diversity	18.648; .243**	4.974; .105*	
H_2O Availability	NS	NS	
Perch Availability	21.464; .271**	7.007; .15*	
Topographic Heterogeneity	38.87.408**	17.359; .325**	

Numbers denote F; adj. R^2, * = $p<.05$, ** = $p<.01$; NS = Not statistically significant.

Table 9. Regression Analysis

Number of Horned Lark vs. Measured Variables	Spring	Spring Creosote
Perennial % Cover	NS	NS
Perennial Species Richness	NS	NS
Creosote Bush Relative Cover	NS	NS
Annual Species Richness	NS	7.167; .339*
Annual Biomass	NS	7.167; .339*
Elevation	NS	NS
Soil pH	NS	NS
Soil Permeability	NS	NS
Non-Measured Variables		
Total Ranks	NS	NS
Amount Pristine	4.452; .059*	4.673; .098*
Vegetation Diversity	NS	NS
H2O Availability	NS	NS
Perch Availability	NS	NS
Topographic Heterogeneity	NS	NS
Number of Raven vs. Measured Variables	**Total**	**Creosote**
Perennial % Cover	NS	5.112; .111*
Perennial Species Richness	NS	9.465; .204**
Creosote Bush Relative Cover (-)	6.767; .09*	8.095; .177**
Annual Species Richness	NS	NS
Annual Biomass	NS	NS
Elevation	NS	6.099; .072*
Soil pH (-)	NS	9.175; .199**
Soil Permeability	NS	NS
Non-Measured Variables		
Total Ranks	NS	7.288; .087**
Amount Pristine	NS	NS
Vegetation Diversity	NS	5.333; .062*
H2O Availability	NS	NS
Perch Availability	NS	NS
Topographic Heterogeneity	NS	12.85; .152**

Numbers denote F; adj. R^2, * =p<.05, ** =p<.01; NS=Not statistically significant.

Table 10. Regression Analysis for Driving Transects

Number of Sightings vs.		
	Spring	**Fall**
Total Ranks	NS	NS
Amount Pristine(-)	NS	NS
Vegetation Diversity	NS	32.752;864**
H2O Availability	NS	15.552;.744*
Perch Availability	49.95;.907**	NS
Topographic Heterogeneity	NS	15.552;744*
Number of Species vs.		
	Spring	**Fall**
Total Ranks	NS	NS
Amount Pristine	NS	NS
Vegetation Diversity	39.862;.886**	NS
H2O Availability	66.667;.929**	NS
Perch Availability	NS	NS
Topographic Heterogeneity	66.667;.929**	NS

Numbers denote F; adj. R^2, degrees of freedom=1,4, *=P<.05, and **=P<.01; NS=Not statistically significant.

Table 11. Regression Analysis for Driving Transects

	Horned Lark	Black-throated Sparrows
	Total	**Spring**
Total Ranks	5.845; .306*	NS
Amount Pristine(-)	8.865; .417*	NS
Vegetation Diversity	NS	NS
H2O Availability	NS	NS
Perch Availability	NS	NS
Topographic Heterogeneity	NS	NS
	Raven	**Red-tailed Hawk**
	Total	**Total**
Total Ranks	NS	NS
Amount Pristine	NS	NS
Vegetation Diversity	5.956; .311*	NS
H2O Availability	8.252; .397*	NS
Perch Availability	NS	6.191; .321*
Topographic Heterogeneity	8.252; .397*	NS

Numbers denote F; adj. R^2, degrees of freedom = 1,4 for spring, 1,10 for the total year, * = $P < .05$, and ** = $P < .01$; NS = Not statistically significant.

FIGURES

KEY TO FIGURES

SPECIES NAMES

BTS	Black-throated Sparrow
E	Empidonax species
HL	Horned Lark
K	American Kestrel
LS	Loggerhead Shrike
R	Common Raven
RCK	Ruby-crowned Kinglet
RTH	Red-tailed Hawk
RW	Rock Wren
SS	Sage Sparrow
ST	European Starling
TV	Turkey Vulture
YRW	Yellow-rumped Warbler

TRANSECT NAMES

AC	Avawatz Creosote
AJ	Avawatz Juniper
BA	Bitter Springs Alkali
BC	Bitter Springs Creosote
BD	Bitter Springs Dune
BDC	Bitter Springs Disturbed Creosote
FC	FISS Creosote
FR	FISS Rock
FW	FISS Wash
GL	Goldstone Lake
GM	Goldstone Mojave
GP	Goldstone Pioneer
GR	Goldstone Rock
GS	Goldstone Driving Transect
MX	Manix Trail Driving Transect
PL	Powerline Road Driving Transect

FIGURE 1

CUMULATIVE FREQUENCY OF MOST COMMON BIRD SPECIES

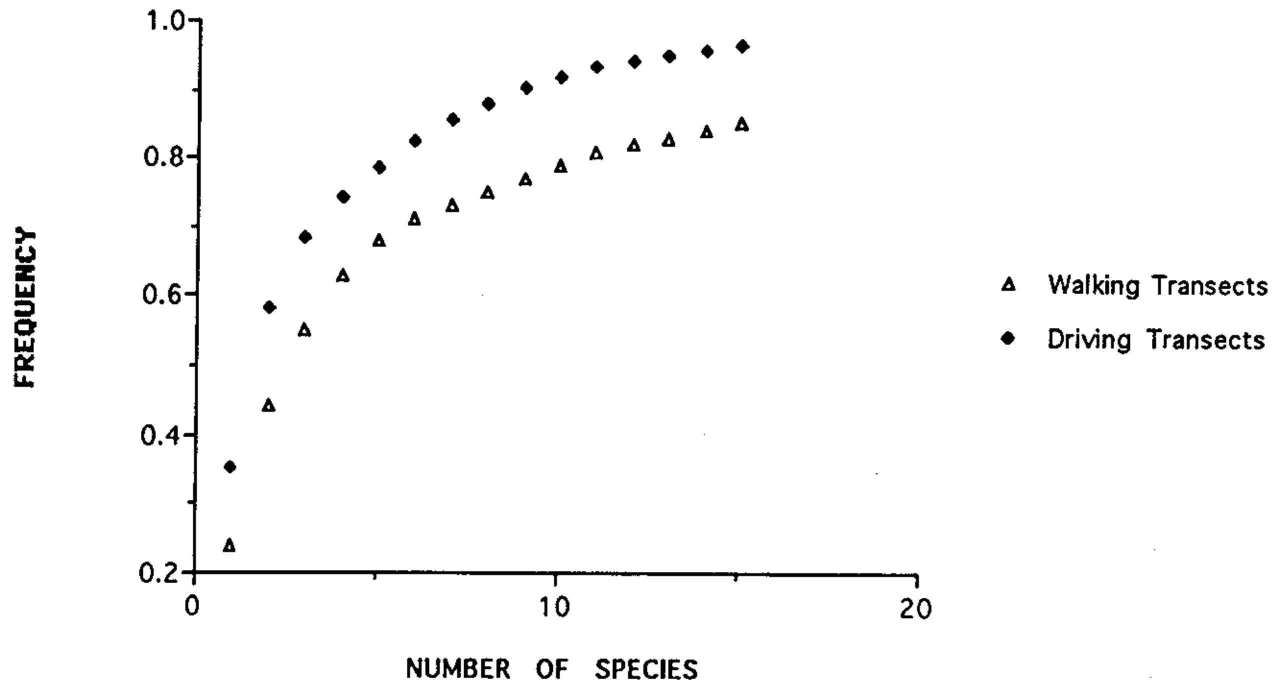
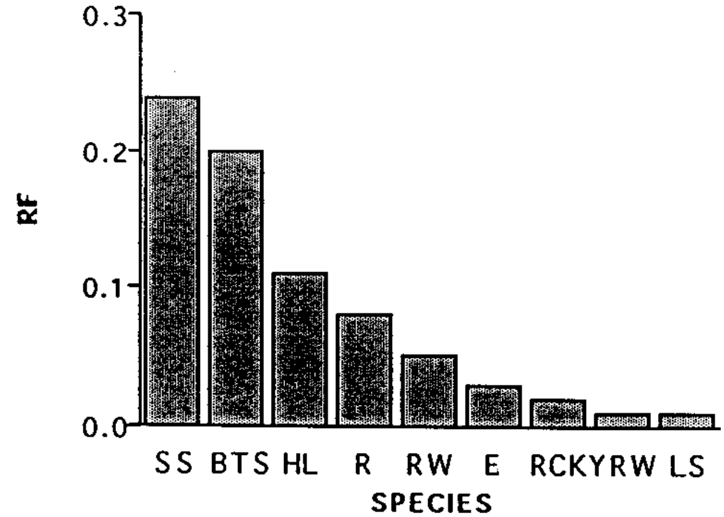
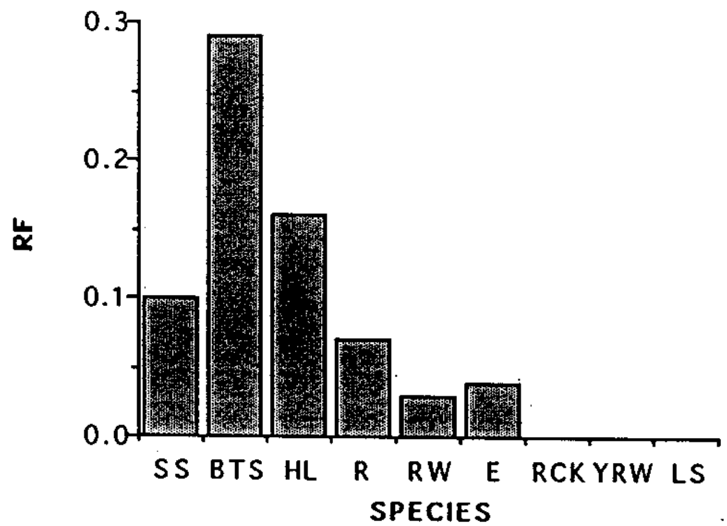


FIGURE 2

RELATIVE FREQUENCY OF MOST COMMON BIRDS



RELATIVE FREQUENCY OF SPRING BIRDS



RELATIVE FREQUENCY OF FALL BIRDS

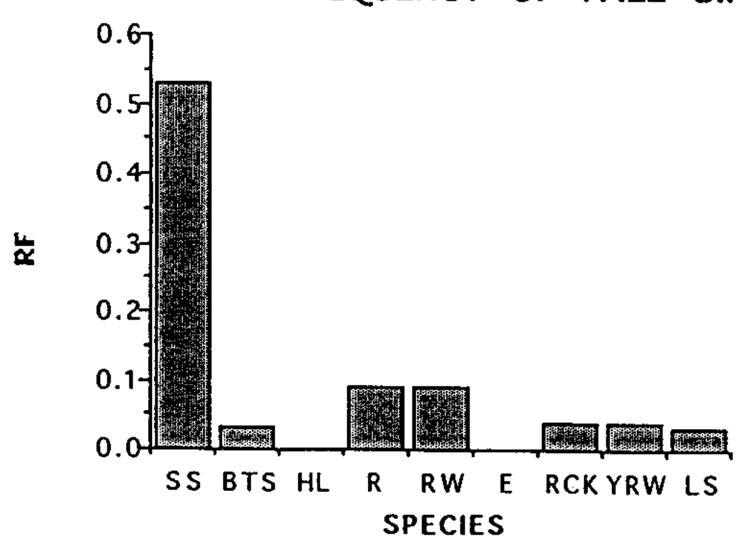
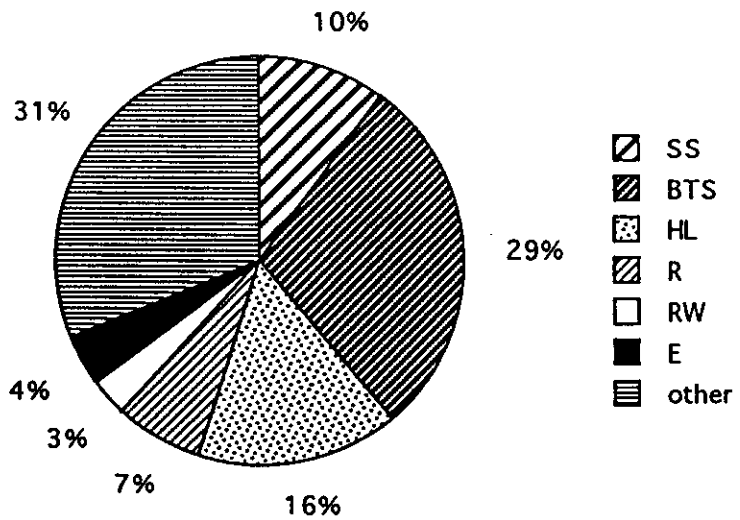
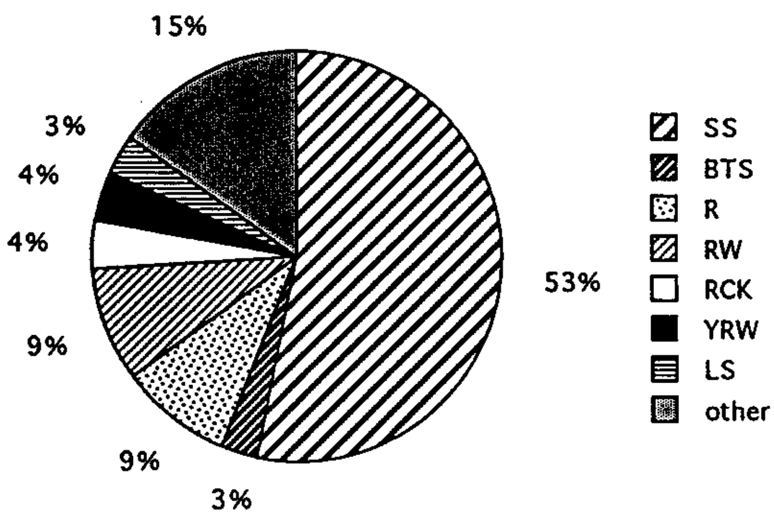


FIGURE 3

RELATIVE FREQUENCY OF SPRING BIRDS BY SPECIES



RELATIVE FREQUENCY OF FALL BIRDS BY SPECIES



RELATIVE FREQUENCY OF CREOSOTE BUSH BIRDS BY SPECIES

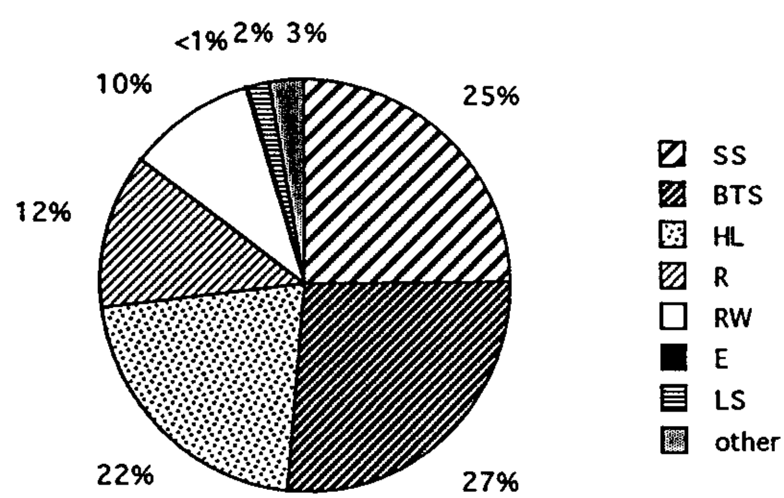
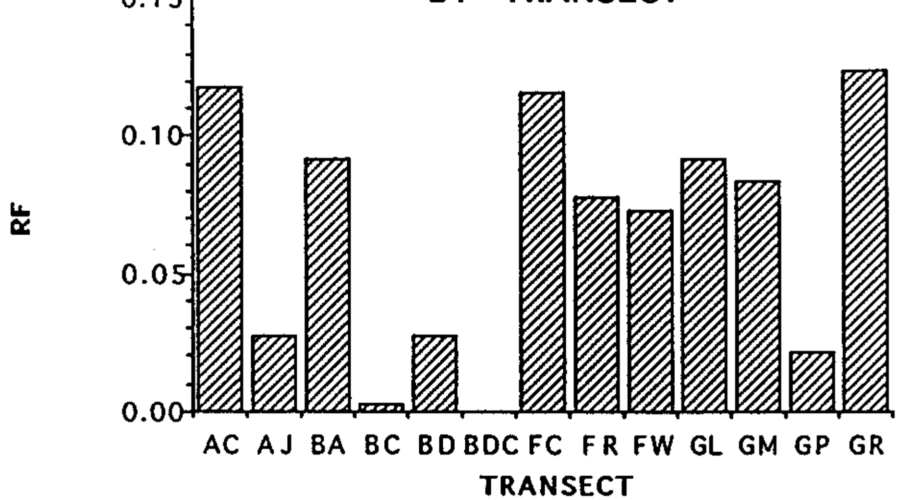
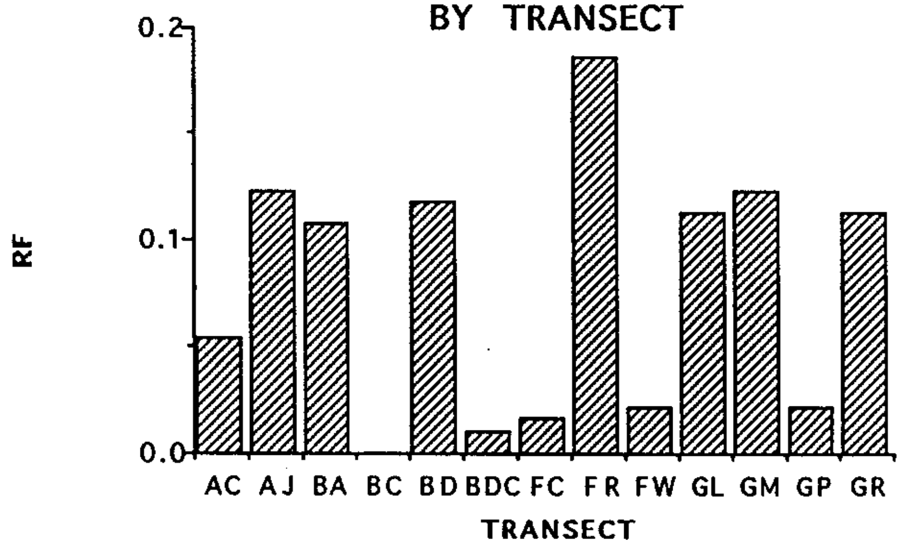


FIGURE 4

RELATIVE FREQUENCY OF SPRING SIGHTINGS BY TRANSECT



RELATIVE FREQUENCY OF FALL SIGHTINGS BY TRANSECT



RELATIVE FREQUENCY OF CREOSOTE BUSH SIGHTINGS BY TRANSECT

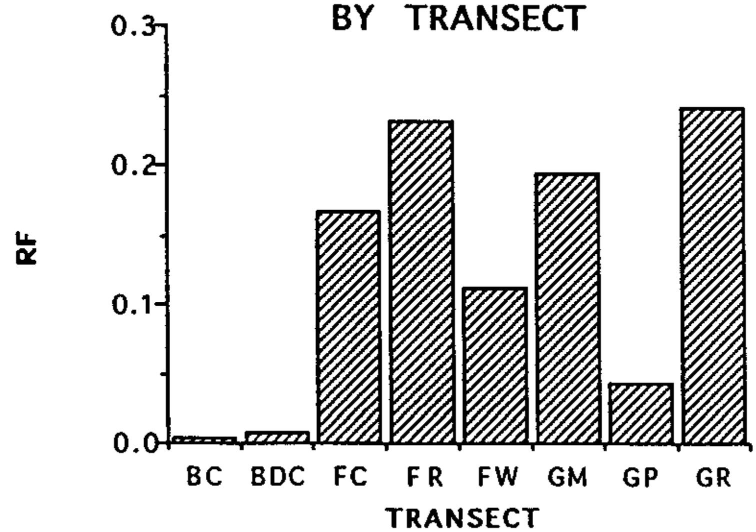
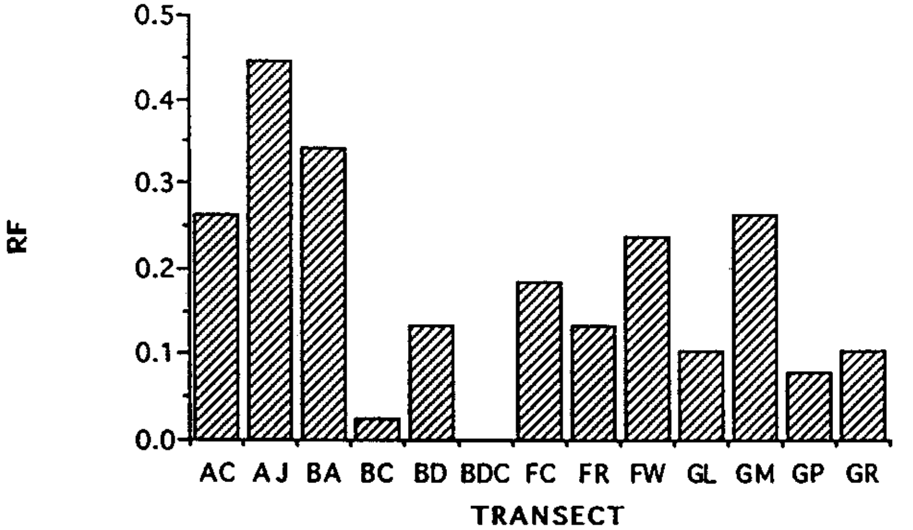
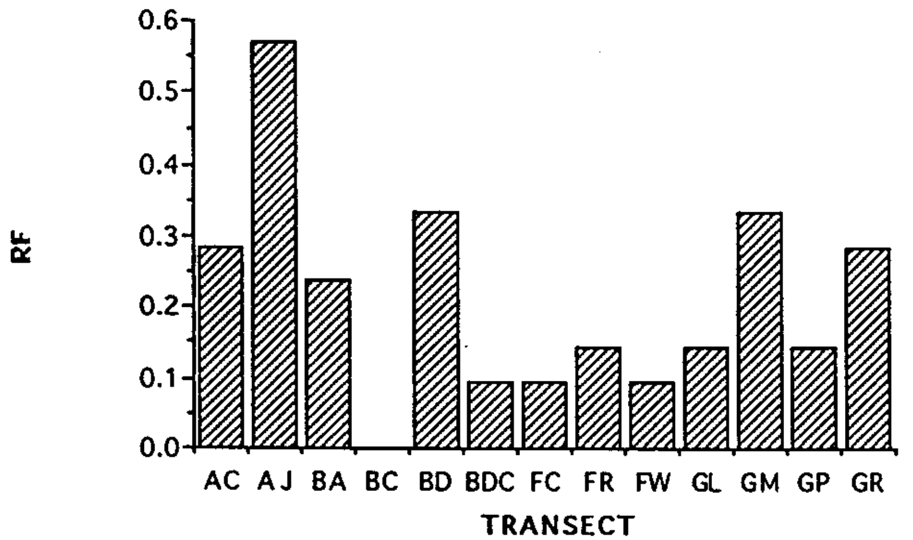


FIGURE 5

RELATIVE FREQUENCY OF NUMBER OF SPECIES IN SPRING



RELATIVE FREQUENCY OF NUMBER OF SPECIES IN FALL



RELATIVE FREQUENCY OF NUMBER OF SPECIES IN CREOSOTE BUSH

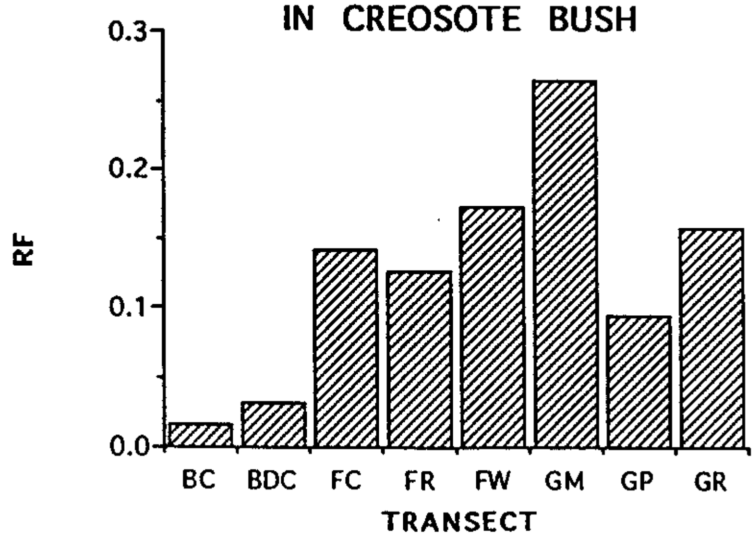
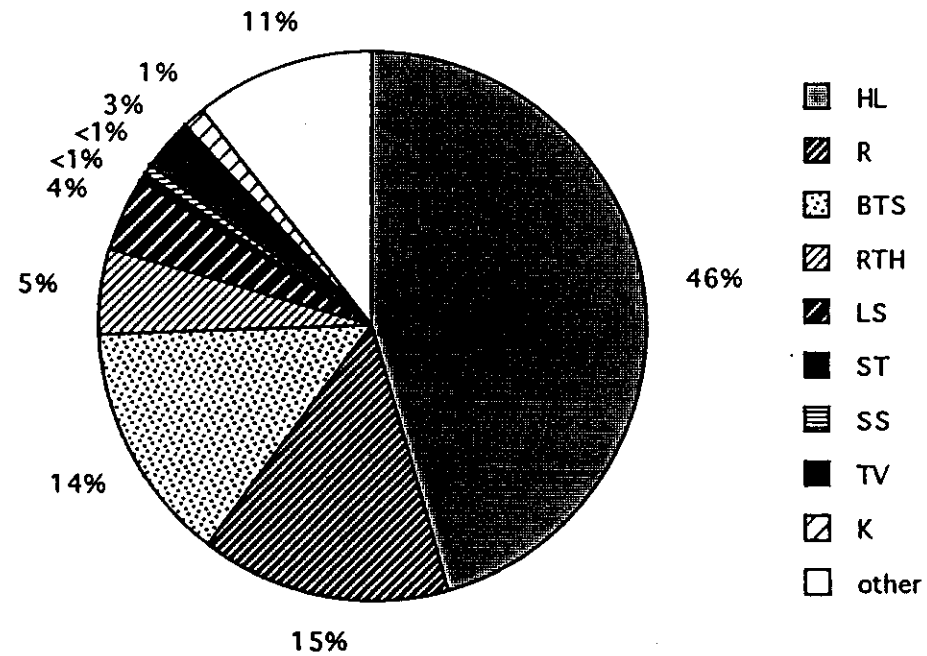


FIGURE 6

RELATIVE FREQUENCY OF SPRING DRIVING TRANSECT BIRDS



RELATIVE FREQUENCY OF FALL DRIVING TRANSECT BIRDS

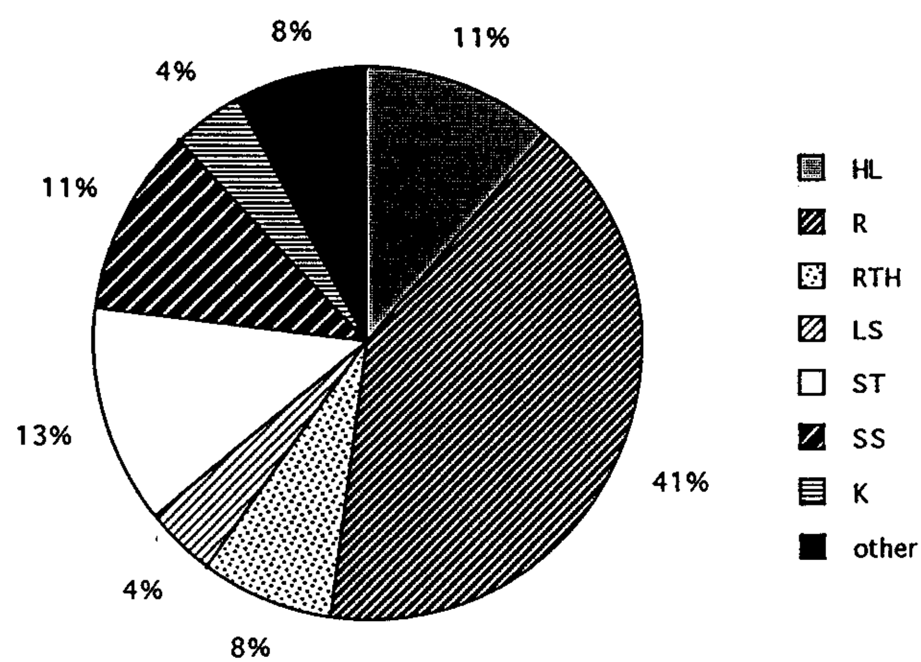
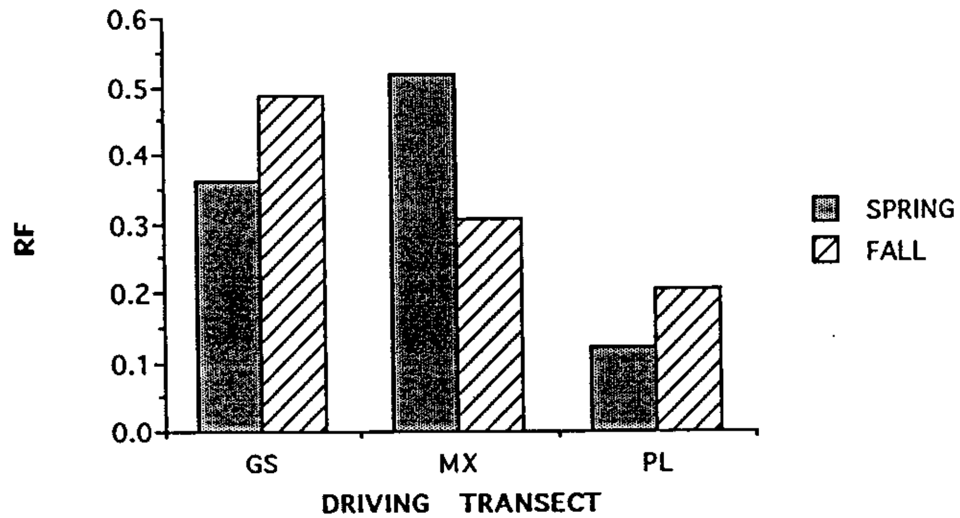
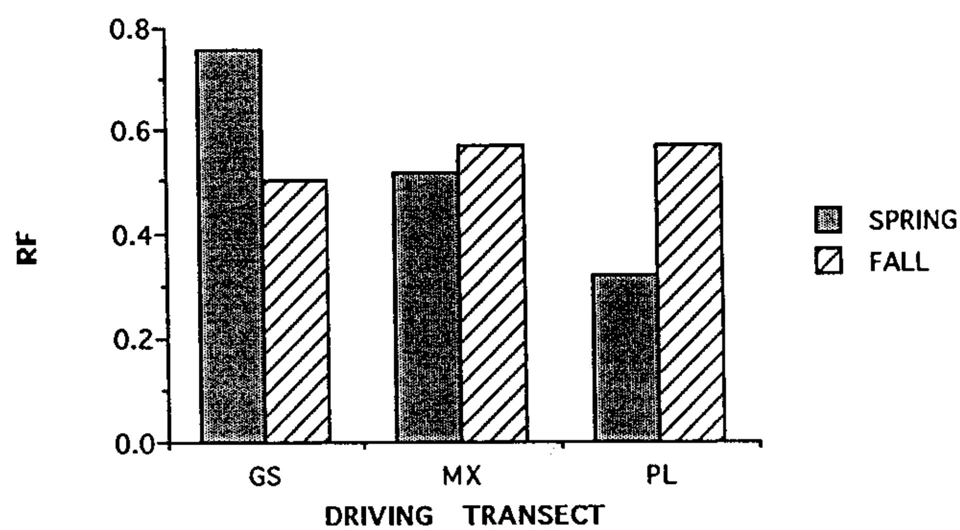


FIGURE 7

RELATIVE FREQUENCY OF NUMBER OF SIGHTINGS ON DRIVING TRANSECTS



RELATIVE FREQUENCY OF NUMBER OF SPECIES ON DRIVING TRANSECTS



APPENDIX A

STATISICAL TESTS

STATISTICAL TESTS

ANOVA

Analysis of variance (ANOVA) is used to determine if a difference exists between groups subjected to a particular treatment. For field biology, the ANOVA follows Model II: treatments are not under the researcher's control. An example of ANOVA for this study is testing for differences between habitats where the variable measured is number of birds. The F-ratio compares the Mean Square (a measure of variance) within groups to the Mean Square between groups. One-factor ANOVA is calculated as follows:

One-factor ANOVA

One-Factor ANOVA

Source of Variation	Sum of Squares (SS)	DF	Mean Square
Among	$\Sigma X_1{}^2/n_1 + ... + \Sigma X_k{}^2/n_k - \Sigma\Sigma X_{ij}{}^2/N$	k-1	$SS_{(among)}$ /(k-1)
Within	$SS_{(total)} - SS_{(among)}$	N-k	$SS_{(within)}$ /(N-K)
Total	$\Sigma\Sigma X_{ij}{}^2 - \Sigma\Sigma X_{ij}{}^2/N$	N-1	

where **k** is the number of groups being sampled, **n** is the number of measurements receiving treatment i, X_{ij} is the jth measurement of the ith treatment group, X_i represents the mean of the ith level, **X** is the grand mean, and **N** is the combined sample size of the treatment groups.

$$F = MS_{among}/MS_{within}$$

There are two kinds of degrees of freedom for the F statistic: k-1 and N-k. Both of these must be used determine levels of significance of F. A significant F means that a difference exists between groups, but does not specify which group means fall outside of expected variation for the group as a whole.

Two-Factor ANOVA with replication

Two-factor ANOVA allows one to test for differences between groups when two treatments have been applied (for example, between habitat and season for number of birds). With two-factor ANOVA, in addition to results for the individual groups, there is a test for **interaction** between treatments. Significant levels of interaction result when the total amount of variation is greater than or less than the sum of within group variation. This means that the effect of one treatment is not independent of the effect of the other treatment. In the following example, results of a study would be laid out as follows, where **a** and **b** are the two factors or treatments (three levels for a and two for b), **X** is an individual measurement, and **T** is the mean for each **cell**, or pairwise combination of a and b.

		Levels of Factor A			
		a_1	a_2	a_3	Total
Factor B Levels	b_1	X_{111} X_{112} T_1 X_{113}	X_{121} X_{122} T_2 X_{123}	X_{131} X_{132} T_3 X_{133}	ΣX_{b1}
	b_2	X_{211} X_{212} T_4 X_{213}	X_{221} X_{222} T_5 X_{223}	X_{231} X_{232} T_6 X_{233}	ΣX_{b2}
	Total	$\Sigma Xa1$	$\Sigma Xa1$	$\Sigma Xa1$	$\Sigma\Sigma X_{ijs}$

The calculation of a two-factor ANOVA from the table above is shown below:

Source of Variation	Sum of Squares (SS)	DF	Mean Square
Factor A	$(\Sigma X_{a1})^2 / n_a + \ldots + (\Sigma X_{a3})^2 / n_a - (\Sigma\Sigma\Sigma X_{ijs})^2 / N$	k-1	$SS_{(A)}$ / k-1
Factor B	$(\Sigma X_{b1})^2 / n_b + \ldots + (\Sigma X_{b3})^2 / n_b - (\Sigma\Sigma\Sigma X_{ijs})^2 / N$		$SS_{(B)}$ / r-1
Cells	$(T_1)^2 / S + \ldots + (T_6)^2 / S - (\Sigma\Sigma\Sigma X_{ijk})^2 / N$		
Interaction	$SS_{(cells)} - [SS_{(A)} + SS_{(B)}]$	(k-1) (r-1)	$SS_{(cells)}$ / (k-1) (r-1)
Within	$SS_{(total)} - SS_{(cells)}$	rk (S-1)	$SS_{(within)}$ / rk (S-1)
Total	$(X_{111})^2 + \ldots + (X_{233})^2 - (\Sigma\Sigma\Sigma X_{ijs})^2 / N$	N-1	

where **T** represents the sum of the X_{ijk} measurements of a cell, **S** is the number of replicates per cell, n_a the number of observations per column, n_b the number of observations per row, **k** the number of columns, **r** the number of rows, and **N** = (k)(r)(S).

Regression Analysis

Two measured variables may be related to each other in a linear fashion. Such a relationship is described as follows: **Y** = **a** + **bX**, where **Y** is the dependent variable, **X** is the independent variable, **a** is the Y-intercept, and **b** is the regression coefficient. **b** is determined in the following way:

$$b = SS_{(XY)}/SS_{(X)}.$$

where the $SS_{(XY)} = \Sigma(XY) - (\Sigma X)(\Sigma Y)/N$ and $SS_{(X)} = \Sigma X^2 - (\Sigma X)^2/N$, while **a** is calculated:

$$a = Y - bX$$

Significance of the regression coefficient is determined using $F = MS_{(R)}/MS_{(W)}$ (mean square of regression/mean square of within regression). Degrees of freedom are 1 and N-2. Mean squares are calculated below:

Source of Variation	Sum of Squares	DF	MS
Regression	$SS_{(XY)}{}^2/SS_{(X)}$	1	$SS_{(R)}/1$
Within Regression	$SS_{(Y)} - SS_{(XY)}{}^2/SS_{(X)}$	N-2	$SS_{(W)}/N-2$
Total	$SS_{(Y)}$	N-1	

where **N** is the number of paired observations, $SS_{(X)} = \Sigma X^2 - (\Sigma X)^2/N$, $SS_{(XY)} = \Sigma XY - (\Sigma X)(\Sigma Y)/N$, and $SS(Y) = \Sigma Y^2 - (\Sigma Y)^2/N$.

Linear Correlation

Correlation is used to examine the relationship between two independent variables, where neither variable is considered to be dependent on the other. **Pearson's correlation coefficient** is calculated as follows:

$r = SS_{XY}/\sqrt{(SS_X)(SS_Y)}$, where the sums of squares are calculated as shown above. r varies between 1 and -1; 1 being a 100% correlation between the two variables, 0 being no relationship, and -1 being a 100% correlation where the two variables are inversely related. Degrees of freedom are N-2. r^2, the **coefficient of determination**, is the proportion of the total variation which is explained by the relationship between X and Y.

APPENDIX B

Walking and Driving Transect Results

Table B-1. Avawatz Walking Transect Results

BIRD SPECIES	AC	AJ
Red-tailed Hawk	-	[1]*,**
Golden Eagle	-	[1]
American Kestrel	-	[1]
Greater Roadrunner	6***	2
White-throated Swift	-	3
Ladder-backed Woodpecker	-	[1]
Western Wood-Pewee	-	3
Empidonax species	8	5
Say's Phoebe	-	1
Common Raven	-	2 [2]
Rock Wren	-	2 [1]
Bewick's Wren	[1]	-
Ruby-crowned Kinglet	2 [2]	1 [5]
Blue-gray Gnatcatcher	6	5
Hermit Thrush	-	1
Bendire's Thrasher	-	[1]
Loggerhead Shrike	-	[1]
Yellow-rumped Warbler	[2]	-
Townsend's Warbler	-	2
MacGillivray's Warbler	-	3
Wilson's Warbler	3	4
Western Tanager	-	2
Black-headed Grosbeak	1	-
Green-tailed Towhee	-	1
Brewer's Sparrow	1	-
Black-throated Sparrow	15 [2]	15 [1]
Sage Sparrow	[2]*,**	[4]
White-crowned Sparrow	1***	3
Dark-eyed Junco	-	[4]
Western Meadowlark	[1]	-
Scott's Oriole	1	-
TOTALS		
Number of sightings	44 [10]	55 [23]
Number of species	10 [6]	17 [12]
Total number of species (Spring and Fall combined)	14	25

Note: * numbers are totals for four repetitions
** numbers in brackets denote Fall sightings
*** numbers not in brackets denote Spring sightings

Table B-2. Bitter Springs Walking Transect Results

BIRD SPECIES	BSC	BSDC	BSD	BSA
American Kestrel	-	-	[1]*,**	-
Mourning Dove	-	-	-	3***
Empidonax species	1	-	-	2
Say's Phoebe	-	-	-	1 [1]
Horned Lark	-	-	3	-
Barn Swallow	-	-	-	1
Common Raven	-	[1]	4 [1]	3
Rock Wren	-	-	[1]	-
Bewick's Wren	-	-	-	[3]
Northern Mockingbird	-	-	-	1
Bendire's Thrasher	-	-	[1]	-
Phainopepla	-	-	-	3
Loggerhead Shrike	-	-	1 [1]	[1]
Orange-crowned Warbler	-	-	-	10
Yellow-rumped Warbler	-	-	1 [4]	[1]
Wilson's Warbler	-	-	-	1
Brewer's Sparrow	-	-	-	4
Black-throated Sparrow	-	-	-	2
Sage Sparrow	-	[1]	1 [13]	1 [14]
White-crowned Sparrow	-	-	-	2
TOTALS				
Number of sightings	1 [0]	0 [2]	10 [22]	34 [20]
Number of species	1 [0]	0 [2]	5 [7]	13 [5]
Total number of species (Spring and Fall combined)	1	2	8	16

Note: * numbers are totals for four repetitions
** numbers in brackets denote Fall sightings
*** numbers not in brackets denote Spring sightings

Table B-3. FISS Walking Transect Results

BIRD SPECIES	FC	FR	FW
Red-tailed Hawk	-	-	1*,**
Prairie Falcon	-	-	1
Mourning Dove	2	1	-
Lesser Nighthawk	2	-	-
Say's Phoebe	1	-	-
Ash-throated Flycatcher	-	-	1
Horned Lark	28	12	8
Common Raven	1	2 [2]***	3 [1]
Cactus Wren	-	-	2
Rock Wren	[2]	5 [2]	[3]
Loggerhead Shrike	-	-	2
Wilson's Warbler	-	-	1
Black-throated Sparrow	7	9	8
Sage Sparrow	2	[31]	-
White-crowned Sparrow	[1]	-	-
TOTALS			
Number of sightings	43 [3]	29 [35]	27 [4]
Number of species	7 [2]	5 [3]	9 [2]
Total number of species (Spring and Fall combined)	9	6	10

Note: * numbers are totals for four repetitions
** numbers not in brackets denote Spring sightings
*** numbers in brackets denote Fall sightings

Table B-4. Goldstone Walking Transect Results

BIRD SPECIES	GSR	GSP	GSL	GSM
Red-tailed Hawk	-	-	-	[1]*,**
Chukar	[2]	-	-	-
Mourning Dove	-	-	-	1***
Ladder-backed Woodpecker		-	-	-3 [4]
Say's Phoebe	6 [1]	-	-	-
Ash-throated Flycatcher		-	-	-1
Horned Lark		-	5	3-
Common Raven		6 [4]	1 [1]	2 [3]2 [2]
Cactus Wren		-	-	-4
Rock Wren		6 [8]	-	--
Le Conte's Thrasher		-	-	[1]1
Loggerhead Shrike	-	[1]	-	[1]
European Starling	-	-	-	1 [2]
Black-throated Sparrow		28 [2]	2	219
Sage Sparrow		[4]	[2]	27 [17]5 [11]
Red-winged Blackbird	-	-	-	[2]
House Finch	-	-	-	4
TOTALS				
Number of sightings	46 [21]	8 [4]	34 [21]	31 [23]
Number of species	4 [6]	3 [3]	4 [3]	10 [7]
Total number of species				
(Spring and Fall combined)	6	5	5	13

Note: * numbers are totals for four repetitions
** numbers in brackets denote Fall sightings
*** numbers not in brackets denote Spring sightings

Table B-5. Goldstone Spring Fifth Repeat

BIRD SPECIES	GSR	GSP	GSL	GSM
Red-tailed Hawk	-	2*	-	1
American Kestrel	-	-	1	-
Costa's Hummingbird	1	-	-	-
Horned Lark	-	1	1	-
Common Raven	1	-	-	1
Black-throated Sparrow	3	3	-	3
TOTALS				
Number of sightings	4	6	2	5
Number of species	3	3	2	3

Note: * numbers are for one iteration

Table B-6. Driving Transect Results

BIRD SPECIES	GS	MX	PL
Turkey Vulture	9*,**	-	1
Northern Harrier	-	[1]***	-
Red-tailed Hawk	5 [3]	1 [2]	10 [4]
Golden Eagle	1	1 [2]	-
American Kestrel	3 [4]	1	[1]
Prairie Falcon	-	-	[1]
Greater Roadrunner	3	-	-
Great Horned Owl	2	-	-
Long-eared Owl	1	-	-
Vaux's Swif	-	1	-
Say's Phoebe	5	[1]	2
Horned Lark	9	135 [13]	2
Tree Swallow	-	1	-
Common Raven	21 [31]	9 [14]	17 [3]
Cactus Wren	-	-	1
Rock Wren	-	[1]	-
American Robin	[2]	-	-
Le Conte's Thrasher	1	-	-
Loggerhead Shrike	9 [4]	1	4 [1]
European Starling	2 [5]	-	[10]
Orange-crowned Warbler	1	-	-
Yellow-rumped Warbler	6	-	-
Townsend's Warbler	-	1	-
Hermit Warbler	-	1	-
MacGillivray's Warbler	-	1	-
Black-throated Sparrow	31	12	2
Sage Sparrow	1 [8]	1 [2]	[3]
White-crowned Sparrow	2	-	[1]
Brewer's Blackbird	3*,**	-	-
TOTALS			
Number of sightings	115 [57]***	166 [36]	39 [24]
Number of species	19 [7]	13 [8]	8 [8]
Total number of species	20	16	13

Note: * numbers are totals for four repetitions
** numbers not in brackets denote Spring sightings
*** numbers in brackets denote Fall sightings

APPENDIX C

Fort Irwin Bird List
Raven Sightings and Group Size

FORT IRWIN BIRDS 1994

Order Podicipediformes
- Family Podicipedidae: Grebes
  - **Pied-billed Grebe**
  - **Horned Grebe**
  - **Eared Grebe**

Order Ciconiiformes
- Family Ardeidae: Bitterns and Herons
  - **Great Egret**
  - **Cattle Egret**

Order Anseriformes
- Family Anatidae: Swans, Geese, and Ducks
  - **Wood Duck**
  - **Green-winged Teal**
  - **Mallard**
  - **Blue-winged Teal**
  - **Cinnamon Teal**
  - **Northern Shoveler**
  - **Gadwall**
  - **American Widgeon**
  - **Canvasback**
  - **Redhead**
  - **Ring-necked Duck**
  - **Lesser Scaup**
  - **Bufflehead**
  - **Ruddy Duck**

Order Falconiformes
- Family Cathartidae: American Vultures
  - **Turkey Vulture**
- Family Accipitridae: Kites, Hawks, Eagles, and Allies
  - **Northern Harrier**
  - **Sharp-shinned Hawk**
  - **Cooper's Hawk**
  - **Swainson's Hawk**
  - **Red-tailed Hawk**
  - **Golden Eagle**
- Family Falconidae: Caracaras and Falcons
  - **American Kestrel**
  - **Prairie Falcon**

Order Galliformes
- Family Phasianidae: Partridges, Grouse, Turkeys, and Quail
  - **Chukar (I)**
  - **Gambel's Quail**

Order Gruiformes
- Family Rallidae: Rails, Gallinules, and Coots
  - **Black Rail**
  - **Virginia Rail**
  - **Sora**
  - **American Coot**

Order Charadriiformes

Family Charadriidae: Plovers and Lapwings

Killdeer

Family Recurvirostridae: Stilts and Avocets

Black-necked Stilt

American Avocet

Family Scolopacidae: Sandpipers, Phalaropes, and Allies

Spotted Sandpiper

Common Snipe

Red-necked Phalarope

Family Laridae: Skuas, Gulls, Terns, and Skimmers

Bonaparte's Gull

Ring-billed Gull

California Gull

Order Columbiformes

Family Columbidae: Pigeons and Doves

Ringed Turtle-Dove (I)

Mourning Dove

Order Cuculiformes

Family Cuculidae: Cuckoos, Roadrunners, and Anis

Greater Roadrunner

Order Strigiformes

Family Tytonidae: Barn Owls

Barn Owl

Family Strigidae: Typical Owls

Great Horned Owl

Burrowing Owl

Long-eared Owl

Order Caprimulgiformes

Family Caprimulgidae: Goatsuckers

Lesser Nighthawk

Order Apodiformes

Family Apodidae: Swifts

Vaux's Swift

White-throated Swift

Family Trochilidae: Hummingbirds

Black-chinned Hummingbird

Costa's Hummingbird

Rufous Hummingbird

Order Coraciiformes

Family Alcedinidae: Kingfishers

Belted Kingfisher

Order Piciformes

Family Picidae: Woodpeckers and Allies

Ladder-backed Woodpecker

Northern Flicker

Order Passeriformes

Family Tyrannidae: Tyrant Flycatchers

Western Wood-Pewee
Empidonax species
Black Phoebe
Say's Phoebe
Ash-throated Flycatcher
Cassin's Kingbird
Western Kingbird

Family Alaudidae: Larks

Horned Lark

Family Hirundinidae: Swallows

Tree Swallow
Violet-green Swallow
Northern Rough-winged Swallow
Cliff Swallow
Barn Swallow

Family Corvidae: Jays, Magpies, and Crows

Common Raven

Family Remizidae: Verdin

Verdin

Family Troglodytidae: Wrens

Cactus Wren
Rock Wren
Canyon Wren (1993)
Bewick's Wren
Marsh Wren

Family Muscicapidae: Old World Warblers, Old World Flycatchers, Thrushes, and Wrentit

Ruby-crowned Kinglet
Blue-gray Gnatcatcher
Black-tailed Gnatcatcher
Mountain Bluebird
Hermit Thrush
American Robin

Family Mimidae: Mockingbirds, Thrashers, and Allies

Northern Mockingbird
Bendire's Thrasher
Crissal Thrasher
Le Conte's Thrasher

Family Motacillidae: Wagtails and Pipits

American Pipit

Family Bombycillidae: Waxwings

Cedar Waxwing

Family Ptilogonatidae: Silky-flycatchers

Phainopepla

Family Laniidae: Shrikes

Loggerhead Shrike

Family Sturnidae: Starlings and Allies

European Starling (I)

Family Vireonidae: Vireos

Bell's Vireo
Gray Vireo
Solitary Vireo
Warbling Vireo

Family Emberizidae: Wood-Warblers, Bananaquit, Tanagers, Cardinals, Grosbeaks, Emberizines, Blackbirds, and Allies

Orange-crowned Warbler
Nashville Warbler
Virginia's Warbler
Yellow Warbler
Yellow-rumped Warbler
Black-throated Gray Warbler
Townsend's Warbler
Hermit Warbler
MacGillivray's Warbler
Common Yellowthroat
Wilson's Warbler
Western Tanager
Black-headed Grosbeak
Lazuli Bunting
Green-tailed Towhee
American Tree Sparrow
Chipping Sparrow
Brewer's Sparrow
Lark Sparrow
Black-throated Sparrow
Sage Sparrow
Savannah Sparrow
Song Sparrow
Lincoln's Sparrow
White-crowned Sparrow
Dark-eyed Junco
Red-winged Blackbird
Western Meadowlark
Yellow-headed Blackbird
Rusty Blackbird
Brewer's Blackbird
Great-tailed Grackle
Brown-headed Cowbird
Northern Oriole
Scott's Oriole

Family Fringillidae: Fringilline and Cardueline Finches and Allies

House Finch
Lesser Goldfinch

Family Passeridae: Old World Sparrows

House Sparrow (I)

Total # of species: 138
I = introduced species

Raven Sightings and Group Size

WALKING TRANSECT	SIGHTINGS/KM	MAX. GROUP SIZE
AC	0 [0]	0 [0]
AJ	0.5 [0.5]	1 [2]
BSA	0.750[0]	2 [0]
BSC	0 [0]	0 [0]
BSD	1.0 [0.25]	2 [1]
BSDC	0 [0.25]	0 [1]
FC	0.25 [0]	1 [0]
FR	0.5 [0.5]	2 [2]
FW	0.75 [0.5]	2 [1]
GSL	0.5 [0.75]	1 [2]
GSM	0.5 [0.75]	1 [1]
GSP	0.25 [0.25]	1 [1]
GSR	1.5 [1]	2 [3]
DRIVING TRANSECT		
GS	0.33 [0.48]	5 [9]
MX	0.28 [0.43]	2 [5]
PL	0.53 [0.09]	7 [2]

Sightings/km is the mean number of sightings per kilometer (the Goldstone spring fifth repeats are not included). Max. group size is the maximum number of individuals seen on any one visit. Numbers not in brackets denote Spring sightings; numbers in brackets denote Fall sightings.